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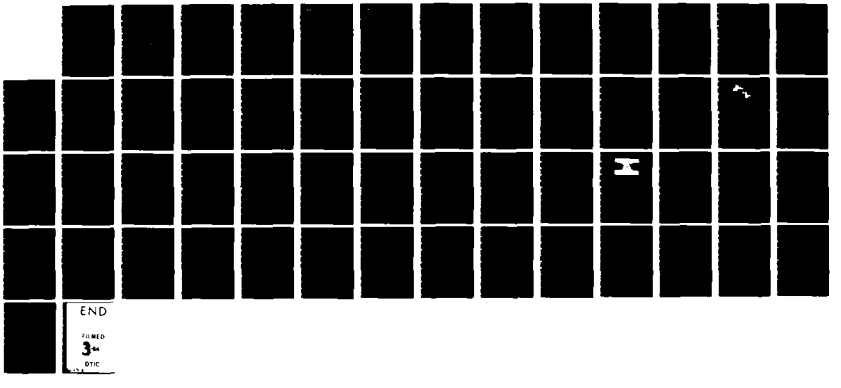

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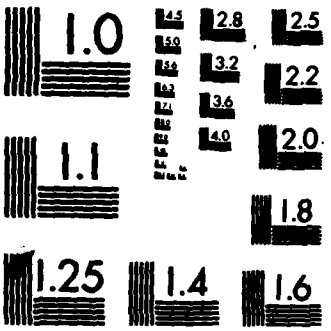

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# EUROPEAN SCIENTIFIC NOTES

ESN 38-3

March 1984




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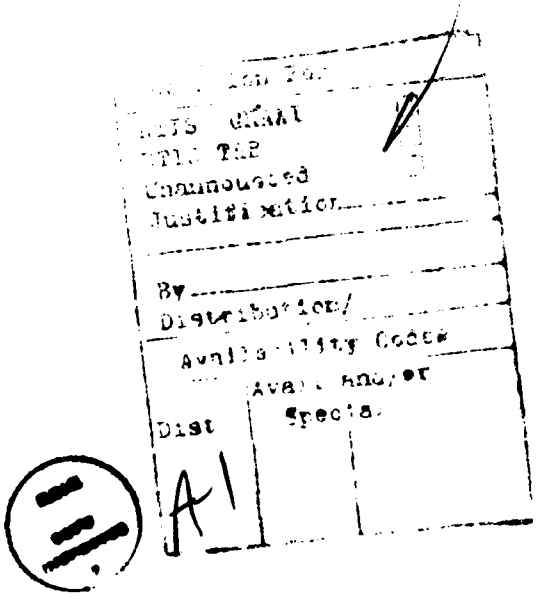

# EUROPEAN SCIENTIFIC NOTES
# OFFICE OF NAVAL RESEARCH
# LONDON

Commanding Officer ..... CAPT M.A. Howard, USN
Scientific Director ..... James W. Daniel
Editor ..... Larry E. Shaffer

March 1984
Volume 38
Number 3


## BEHAVIORAL SCIENCES


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Limburg Style ..... Richard E. Snow 115


The medical faculty at Maastricht, The Netherlands, has built an innovative educational and evaluation system.

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# BEHAVIORAL SCIENCES

## EVALUATION OF MEDICAL EDUCATION--LIMBURG STYLE

*by Richard E. Snow. Dr. Snow is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1985 from Stanford University, where he is Professor of Education and Psychology.*

In the early 1970s, a bold experiment in medical education was formulated in The Netherlands. The new medical faculty at Maastricht, in the southernmost province of Limburg, would be dedicated to two innovative propositions. First was the view that the training of primary-care physicians should be problem-based rather than discipline-based--as in traditional, departmentally organized medical schools--and should provide for a substantial degree of self-directed learning by students rather than teacher-controlled instruction. Second, it was believed that institutions of higher education, and particularly those engaged in medical training, ought to be designed to provide continuous longitudinal evaluations of their own performance; in traditional medical schools, performance data are typically collected only to make evaluative decisions about students--not to provide evaluations of institutional effectiveness on the basis of student performance.

A few other medical schools around the world, notably McMaster in Canada and Beersheba in Israel, share with Maastricht the goal of developing and improving problem-oriented instructional programs. These now form a network of institutions watched closely by the United Nations' World Health Organization in Geneva as examples of what might work best for primary-care training in developing countries. However, only in Maastricht has the second goal--of longitudinal institutional evaluation--been pursued and realized.

Maastricht received its first class of 50 medical students in September 1974. Since then, 10 other classes have been enrolled for the 6-year program, with an increasing number of students per class up to the maximum of 150 students per class, reached in September 1982. The medical program served as the centerpiece for Rijksuniversiteit Limburg, founded in 1975, which now includes faculties in law and economics organized also to provide problem-based, self-directed learning programs.

In medicine, each year of the curriculum is organized into blocks consisting of one or more carefully selected health care problems. Students are randomly assigned to small-group tutorials to work through the problems presented to them in each block; they are rerandomized to other groups for the next block. In each group, a faculty tutor facilitates problem-solving by questioning and reasoning but provides no lectures. Students analyze the problems presented, allocate subtasks among themselves as needed, and pursue both common and individual learning goals with respect to the problem at hand. The aim is to achieve group and individual problem solution if possible, but to promote the acquisition of problem-solving and reasoning skills and a great deal of problem-relevant medical knowledge in any event. For each block, a library of printed and audiovisual learning resources is available, and content experts representing the relevant medical science disciplines can be contacted for consultation at any point. Students can also pursue individual projects at certain points and, of course, as the program proceeds there is increasing emphasis on the development of individual clinical skills.

The evaluation system is designed ultimately to assess five kinds of outcomes of the educational program: medical knowledge, clinical skills, problem-solving ability, attitudes and values related to community health care and primary practice, and the overall impact of the institution on community health in the Limburg region. The first four outcomes involve direct assessments of students, both to provide feedback and counseling to students and to serve institutional decisions regarding program improvements. The fifth outcome involves data collection at the level of the regional health care system, as well as follow-up of students after graduation. Research and development supporting the first three kinds of measurements are well along at the time of this writing. Work focused on the fourth and fifth objectives is now under way.

Measures of medical knowledge derive from short objective tests given after each program block and more extensive progress tests given four times per year each year throughout a student's program. The shorter, Block Tests provide immediate feedback to students and to faculty committees responsible for problem block revision. The longer, Progress Tests yield longitudinal

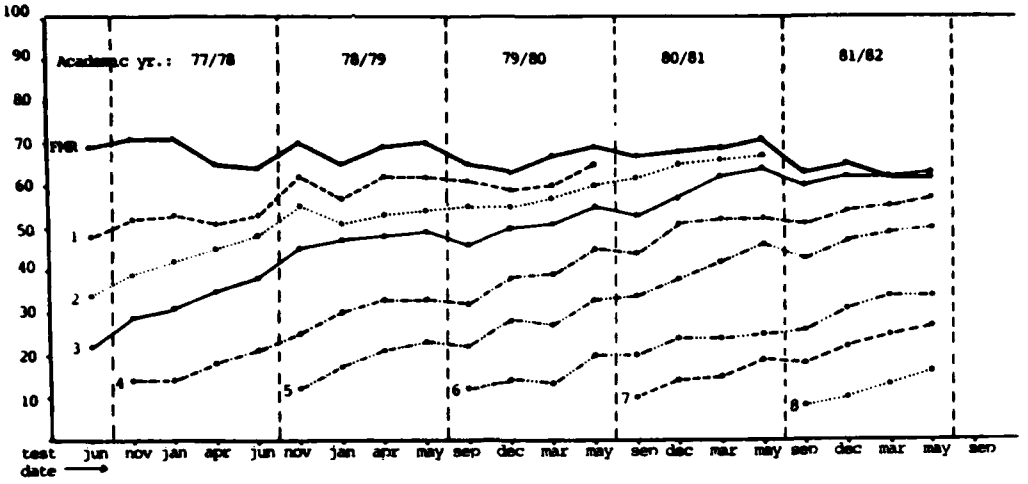


Figure 1. Progress test means for the first eight classes of Maastricht medical students (curves 1 through 8, with classes 1, 2, and 3 beginning study in 1974, 1975, and 1976, respectively) and reference groups of resident physicians (R).

assessments of individual student growth, class-by-class comparisons, and a basis for comparisons with students at other universities, and with groups of practicing physicians. The 250 items of each Progress Test are a representative sample from an item bank of over 10,000 questions designed to measure the factual knowledge in all areas of medical science considered appropriate for a final graduate in medicine. Such tests are thus administrable to any student or physician at any time. Since the tests are comparable (though strictly speaking they are not psychometrically parallel), they provide a rough means of tracing student growth curves over 6 years of education. Furthermore, since the tests are samples from a system of content-knowledge areas, they allow separate growth assessments for content areas such as "respiratory tract," "digestive tract," and "nervous system."

Figure 1 shows a summary of Progress Test data from the first such test in 1977 through the 1981-82 academic year. Each data point is a class mean for a particular test administration. The class beginning the program in 1974 is shown as a curve separately from the class beginning the program in 1975, etc. Of particular interest, in addition to the class-growth curves themselves, is the comparison with the test results obtained from groups of resident physicians practicing in local hospitals elsewhere in The Netherlands (the heavy solid curve). This curve indicates a kind of standard or "ceiling" toward which each class progresses. In such data also, the internal consistency reliabilities of the Progress Tests are shown to be high (alpha ranges from 0.85 to 0.98), as are the interrelations among adjacent tests ($r$ ranges from 0.70 to 0.85); the complete correlation matrix shows the typical simplex pattern for measures in a time series. It is also clear that the Progress Tests do not correlate substantially with intelligence measures ($r$ ranges from 0.15 to 0.20).

Figure 2 provides a comparison in which volunteer students from two more traditional medical schools in The Netherlands also responded to samples of Progress Test items. At the time this cross-sectional study was conducted, no sixth year group yet existed at Maastricht. A reference group of resident physicians is also shown. Other comparison studies have been conducted using tests designed by other medical faculties. These, too, show the Maastricht students to be competitive.

Another interfaculty comparison is shown in Figure 3 for subsets of items concerned only with knowledge of anatomy. In this study, the students from the traditional medical school were chosen randomly. The marked increase in knowledge in the third year of the traditional program reflects the position of traditional anatomy courses in this curriculum; thereafter there is some slight decline. The Maastricht

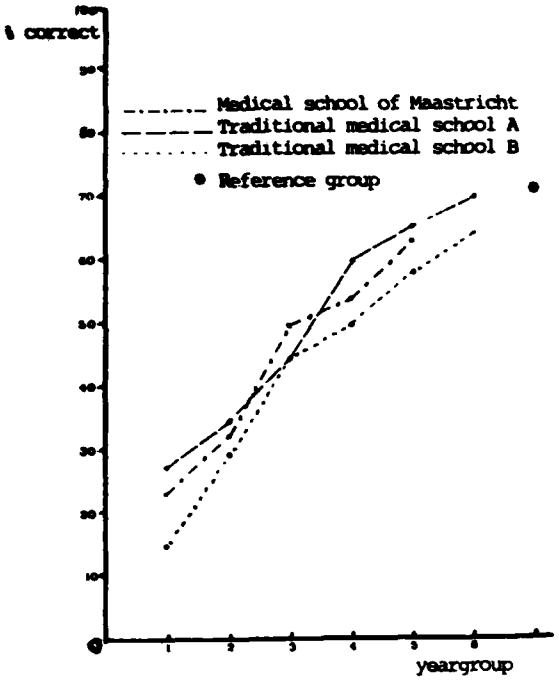


Figure 2. Progress test means for students in their first through sixth year of study at each of three medical schools and a reference group of resident physicians.

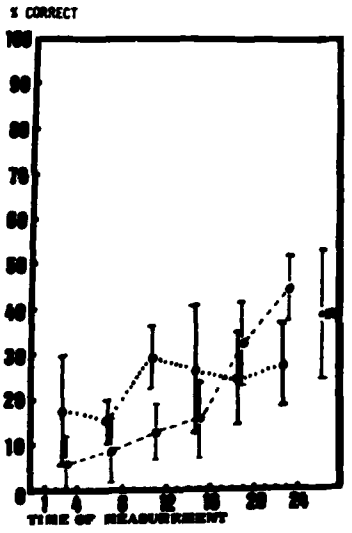


Figure 3. Progress test means and standard deviations in anatomy for students in their first through sixth year of study (test time points 3, 7, 11, 15, 19, 23) in a problem-based (dashed curve) or a traditional (dotted curve) medical education program and a reference group of resident physicians (R).

curve, in contrast, shows a gradual and then a substantial persistent growth in knowledge of anatomy through the more clinical years of the program. The curve exceeds the average for resident physicians. There is no "course" in anatomy at Maastricht, but faculty members report observing persistent interest in the subject among students throughout their problem-based experience and especially in their clinical rotations. Thus with such data the innovative program at Maastricht appears to be allaying initial fears on the part of the medical education community that it would emphasize problem-solving at the expense of medical knowledge.

Other data also confirm that Maastricht is equal to or ahead of other Dutch medical faculties. By the fall of 1981, for example, 88 percent of the Maastricht class of 1974 had received diplomas, and only 2 percent had dropped out; the remaining 10 percent were still in their studies. At other Dutch universities, only 21 percent of the medical students starting in 1974 had completed their programs, 18 percent had dropped out, and 61 percent were still in studies. Figures for other years are comparable. Because in The Netherlands medical school admissions and assignments are determined by a centralized weighted lottery, students in the eight different medical schools represent essentially the same statistical population. These and other comparisons between medical schools planned by the Maastricht Evaluation group may thus be more sensitive to program variations, as opposed to other population factors, than would similar comparisons between US premedical or medical education programs.

The training of clinical skills at Maastricht occurs in a skills laboratory containing a variety of written protocols, audio-visual aids, dummies, and simulated patients. For assessment purposes, skills tests have been developed using a series of stations through which students rotate to perform a variety of skills. At any given station, they may be required, for example, to give first aid, interview a simulated patient, test a urine sample, or perform a neurological examination. Performance is rated by trained observers on standardized checklists. The possibility of building a longitudinal assessment in the skills domain comparable to the Progress Tests is now being studied.

In the problem-solving domain, several assessment techniques have been investigated. There are structured oral examinations and simulated patient encounters in which student and examiner

role-play structured simulations of case histories. The results of examiner interrogations can be scored. Critical-action checklists and rating scales are also used to register student performance with respect to each problem presented. A start has been made to compare Maastricht and other students on such measures, but it is too early to report clear results. Other self-assessment instruments in problem-solving have also been developed for student use. There are patient-management problems, in which students choose from lists of possible actions those to be taken at each step in a case, and modified essay questions also connected to stages in developing biomedical problems and cases. Portable patient-problem packs, in which students sort cards to indicate actions to take in relation to cases, and problem boxes containing realistic presentations of information about cases are also used. So-called Triple Jump Exercises provide similar assessments at the level of clinical clerkships. A combination of these techniques seems to provide a promising approach to the complex problem of analyzing and measuring the important aspects of medical problem-solving processes and skills.

Still ahead at Maastricht lie the additional complex problems of assessing student attitude development and institutional impact with respect to community health in the region. But the educational evaluation group at the University of Limburg, headed by Prof. Dr. Wynand Wijnen, seems equal to these tasks. It has become one of the most productive and successful educational research and evaluation groups working directly in the context of an ongoing medical education program.

It is worth noting also some fundamental contributions to cognitive psychology that seem derivable from this work. Though suggested by the Maastricht data, they will demand much more intensive research therein as the evaluation proceeds.

First, the problem-based instructional program would be expected to produce an organization of knowledge in the student's cognitive system rather different from the organization produced by discipline-defined courses. Because knowledge derived from different disciplines is connected directly to problems to which it is relevant, knowledge organization should be interdisciplinary in a fundamental sense. This organization can be expected to be strengthened each time it is retrieved from memory in the face of related practical problems. And it is practical problems that must be faced each day as a student progresses through clinical training and into primary practice. The structure of a particular discipline may not provide a framework for knowledge organization as lasting as that provided by the structure of a particular kind of problem. Knowledge retention should thus be stronger and more functional with problem organization than with discipline organization, and the data of Figure 3, especially, support this hypothesis.

Second, the psychology and the mathematics of student learning curves over 6 years of development can be analyzed to yield new insights into the processes of complex knowledge acquisition. Little is now known about student trajectories across this substantial a cognitive and time frame because a data base of this sort has never before been available. The models the Maastricht group is now experimenting with may thus identify quantitative and qualitative changes in cognitive growth not before captured empirically.

Third is the potential of the Maastricht research for unraveling some of the complexities of problem-solving ability as seen in the context of real-world rather than laboratory tasks. Knowledge acquisition, problem-solving processes, and motivational and other affective sides of performance are here seen in interaction. And the human idiosyncrasies known to abound in constructive thought are evident. The multivariate assessments being built in this work should provide richer descriptions of these phenomena than those now in hand.

Beyond these contributions, there is the idea in Maastricht that an institution of higher education may actually be able to chart its course through history in terms of empirical data on its effects on students and on the social systems it serves. This is an ideal rarely imagined and never yet realized.

*12/14/83*

## BIOLOGICAL SCIENCES

### A NEW METHOD OF ASSESSING BIOCOMPATIBILITY OF MATERIALS

*by Thomas C. Rozzell. Dr. Rozzell is the Liaison Scientist for Biological Sciences in Europe and the Middle East*

*for the Office of Naval Research's London Branch Office. He is on reassignment until August 1985 from the Office of Naval Research, Arlington, where he is Program Manager for Cellular Biosystems.*

Many types of new materials, especially polymers, are being studied for use as biomaterials. These are quite often used in hematological situations bringing them in contact with blood. When blood contacts an artificial surface, the primary reaction is adhesion and aggregation of platelets, leading to thrombus formation (clotting). Although, theoretically, several assays can be carried out to study clotting, a single, reliable, and rather rapid test has been needed in material assessment and development.

S.K. Bowry and J.M. Courtney of the Bioengineering Unit at the University of Strathclyde, and coworkers at the Royal Infirmary, Glasgow, will soon publish their results on a new method that uses the platelet release reaction (PRRx) to determine the biocompatibility of several polymers, glass, and rubber. Their investigation examined the release reaction from the alpha granules of platelets after the blood contacted the polymer or other material. They used a radioimmunoassay technique to measure the platelet-specific protein, beta thromboglobulin (BTG).

The PRRx is an essential part of the process of platelet aggregation during hemostasis, and clotting is believed to involve cellular secretory activity from the storage granules of platelets. BTG is one of the most abundant proteins released when blood platelets come in contact with foreign surfaces. A measure of this protein, as an indicator of the rate of the overall PRRx, is relevant to an understanding of thrombus formation on synthetic surfaces.

It was found that polypropylene tubes caused less release of BTG than those of siliconized glass, and silicone rubber induced less BTG release than poly(vinyl chloride). A paper has been submitted to *Biomaterials*.

*12/9/83*

## BIOELECTROMAGNETICS AT MILLIMETER-WAVE FREQUENCIES

*by Thomas C. Rozzell.*

In September 1983 the Union de Radio Scientific Internationale (URSI) held a small symposium entitled "Techniques in Studies of Biological Effects of Low-Level Millimeter-Waves." The primary sponsor of the symposium, held near Munich, Federal Republic of Germany, was the URSI Working Group on Measurements Related to the Interaction of Electromagnetic Fields With Biological Systems. Other groups cooperating in the sponsorship of the symposium were the Bioelectromagnetics Society (BEMS), Gesellschaft für Strahlen und Umweltforschung (GSF), and the Max-Planck-Institute für Festkorperforschung (MPIF).

This article analyzes a few key research projects reported at the symposium or recently published. I have not tried to discuss the entire symposium, but have chosen projects that quite clearly are pacesetters or that demonstrate some of the problems the experimentalist faces in conducting research at frequencies in the range between 30 and 100 GHz.

According to Saul Rosenthal, Chairman of the Working Group, the symposium "grew out of the frustration experienced by a number of researchers over the past few years who have attempted the replication of the exciting experiments reported from the USSR nearly a decade ago [Smolyanskaya and Vilenskaya, 1974]. Despite the efforts of a number of experimental groups, consistent and reproducible results have not emerged to elucidate the effects of millimeter-waves on cells and subcellular structures." Much controversy has revolved around several experiments that purported to show a resonant response of yeast, *E. coli*, and other systems to applied microwave energy between about 40 and 60 GHz. In other words, the observed effects varied distinctly with small changes in the exposure frequency. The important question that has arisen is whether this "resonant" behavior is inherent in the biological system or whether it only reflects a resonant phenomenon or instability in the exposure system (Keilmann, 1983). With the attention being paid to the exposure systems today, it seems that the latter can now be ruled out.

It has generally been accepted that the best explanation for frequency-dependent effects at millimeter-wave (and other) frequencies lies in the concept of long-range coherence in macromolecules as put forth by Fröhlich (1968). Fröhlich suggested that critical oscillations exist in macromolecules that determine activity and function of the organism. It is believed that the frequencies of these oscillations lie roughly between 100 and 1000 GHz. It seems reasonable to conjecture that

functional activities occurring at the macromolecular level depend on critical, and perhaps matching, oscillations being present at the right place and time for a given reaction to occur. Such oscillations might be finely tuned and "metastable," in which case small inputs of energy to one or both halves could cause disruption in the progress of the function or reaction. Fröhlich and others actually postulate that there is a type of threshold or limit cycle in metabolic excitation of large-amplitude vibrations (Fröhlich, 1980; Adey, 1981; Kaiser, 1981). Kaiser (1983) has used a rather simple model to explain how a free internal oscillation, of frequency $\omega_o$, can be perturbed and, in fact, entrained by an external field of intensity $F_o$ and frequency $\lambda$ (*sic*). Using an oscillation diagram, he shows graphically how, with $\lambda << \omega_o$, competition between slow external and fast internal oscillation leads to entrainment of $\omega_o$ through a series of quasi-periodic and irregular states. The process is both frequency- and intensity-dependent and could account for the "windows" that have been observed by a number of investigators.

Unlike bioelectromagnetics research at lower frequencies (e.g., 2450 MHz), millimeter-wave research did not grow directly out of a need to assess hazards. Rather, this research has been aimed primarily at the fundamental interactions that occur in cells, membranes, and macromolecules. Thus, in the research discussed below, the microwave energy might be viewed as a tool to probe cellular and macromolecular function and the general nature of electromagnetic field interactions, both intrinsic and extrinsic.

## Experiments With Yeast Cells

Like *E. coli*, yeast cells are extremely popular among biologists and others seeking information on cellular functions such as metabolism, differention, and growth and development. Webb and Dodds (1968) were the first to definitively show in *E. coli* frequency-specific or resonant effects of millimeter-wave energy. Since then, a number of studies have been attempted using several different systems. Roughly half of these have failed to demonstrate the resonance phenomenon, particularly at low intensity levels where thermal effects could be ruled out. In retrospect, we may now be able to speculate on some of the reasons these experiments have "failed"; a list of "do's" and "don'ts" that were developed at the symposium is given at the end of this article.

Yeast cells have produced the most consistent findings of nonthermal, resonant responses, and the most experienced researchers have been the German workers led by Werner Grundler at GFS in Neuherberg and Fritz Keilmann at MPIF in Stuttgart. Essentially, their research used diploid, homozygot, and isogene wild type *Saccharomyces cerevisiae* grown on agar plates for 3 days at 30°C, then stored at 4°C. Cells for exposure (power input from 10 to 25 mW) were taken from these plates after 10 to 16 days and placed in liquid growth medium in small glass cuvettes equipped both with mechanical stirrers and with submersible Teflon antennae for coupling in the microwaves. The simultaneous growth of two yeast cultures (one control and one exposed) was measured in a double-beam spectrometer. When they reported their first experiments, they obtained the curve shown in Figure 1a (Grundler and Keilmann, 1978). They recently published the results obtained during the last

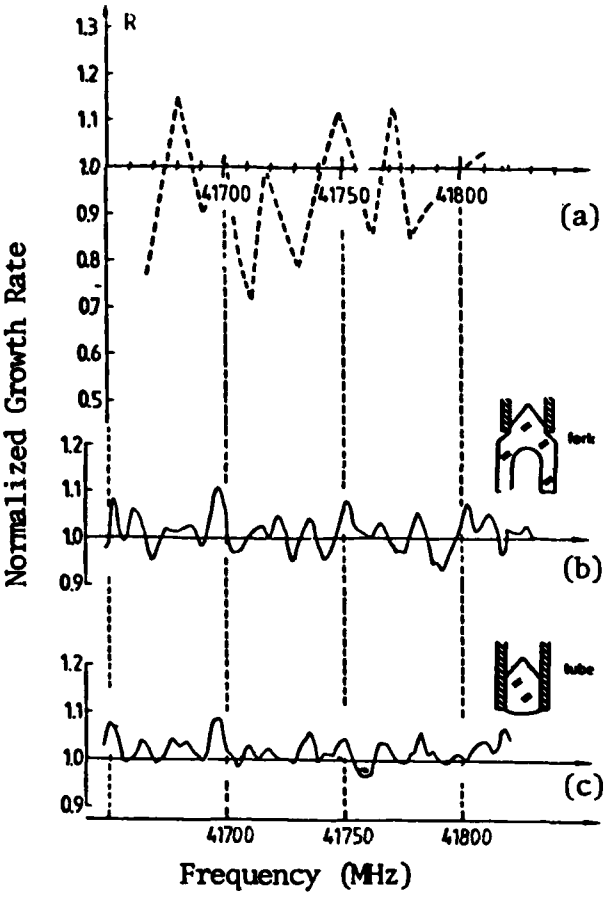


Figure 1. Effects of frequency on growth rate of yeast.

2 years; they used the same yeast system, but with two different antennae (Grundler and Keilmann, 1983). One was the "fork"-shaped antenna used in the earlier experiments and the other was a simpler, cylindrical, "tube"-shaped antenna. The results of these experiments are shown in Figures 1b and 1c.

The most obvious differences between the 1978 and 1983 studies are the apparent increase in resolution, the differences in the degree of change, both positive and negative, and the displacements in frequency for some of the peaks. A cross-correlation test was used to compare the present results (Figures 1b and 1c) with those obtained originally (Figure 1a). They found that maximum correlation is obtained only at a nonzero frequency shift, $\Delta f = -11$ MHz. This indicates that a systematic calibration correction of +11 MHz has to be applied to the previous study--assuming both spectra probed a common feature, i.e., a frequency selective response in the yeast cells. Keilmann and Grundler feel that this correction would be reasonable since it is within the ±20 MHz systematic error margin originally estimated. The reality is that there was a quantum increase in the ability to control the frequency of the microwave source and in the environmental control of the samples. In addition, whereas in the original study the controls and experimentals were done on different days, the recent study used two spectrometers and both sets of samples were run on the same days. Further, temperature was measured and controlled better in the 1983 study.

There is another difference between the spectra of the two types of antennae in the 1983 study. With the "fork" antenna, there was almost an equal number of positive and negative growth rate peaks (Figure 1b). With the "tube" antenna (Figure 1c), almost all of the peaks occur above the "normal" line, with very few real negative-growth rates shown. However, there is excellent correlation between the two sets of curves in terms of the major peaks, and Keilmann does not know why they did not observe the same degree of growth-rate decrease with the "tube" configuration. This study, in which 331 growth experiments were conducted, seems to demonstrate unequivocally that low-level microwaves in the frequency range of 41 to 42 GHz affect yeast growth rate within resonant bands of only 8 MHz, or a total offset of about 16 MHz.

Fröhlich's "Type A" coherent excitation of a single polar mode may explain the effect on the growth rate of *Saccharomyces cerevisiae* (Fröhlich, 1983). Oscillations of this type are long range and give rise to frequency-selective interactions in and between systems (or parts of systems) with equal excitation frequencies. It seems likely that we are dealing here with a membrane phenomenon wherein access of the cell to the nutrient molecules is the key step. One must remember that the membrane has a high electric field, and it follows that the higher the inherent electric field, the closer polarizable molecules will be toward their metastable state. For most large macromolecules--such as proteins, liposomes, or even hemoglobin molecules--the amount of energy necessary to reorient the entire molecule at environmental temperatures is very large. However, intramolecular rearrangement of charge is quite likely, especially as the amount of associated water is varied.

If we assume that some "breakdown" may be occurring in the cell membrane (or polarization of internal structures of membrane proteins), it would be well to gather some information about the membrane capacitance. The capacitance would determine, for example, the charging time of the membrane.

Now that the effect has been well established with the yeast cell culture, it is necessary to take a closer look. Grundler reported at the symposium that he has set up a microscopic arrangement that allows him to view single cells that are locally fixed but in a growth medium. He hopes to be able to define the distribution of the generation time for cell divisions and analyze the effect of the millimeter-waves on different phases of the cell cycle. His system uses a moving stage of a computer-controlled scanning microscope with a flexible antenna that allows continuous exposure directly to the cell chamber on the microscope stage. Such a study leads in the proper direction to solve the mechanism question. In addition, experiments are planned at lower temperatures: 29°C instead of 30.7°C.

## Experiments With Drosophila

Just as yeast and *E. coli* are favorite one-cell organisms for biological study, the fruit fly, *Drosophila melanogaster*, is by far the most studied insect, representing a highly differentiated species that is especially well suited as a model for studies concerned with effects of various agents on genetic material. It is thus surprising that there have been relatively few millimeter-wave investigations using

this insect. Because of its size, it is particularly well suited for high-frequency, short-wavelength studies. However, just as with the yeast, there are some apparent conflicts in the reported results of the work that has been done. For example, Zalyubovskaya (1974) reported decreased fertility (37 to 55 GHz, 10 mW/cm², adult insects), while Dardal'hon et al. (1977) found an increase (17 GHz, 60 mW/cm², adult females only). No evidence has been found for a mutagenic effect of millimeter-waves in the fruit fly.

The most recent study of millimeter-wave effects in *Drosophila*, conducted by Gunter Nimtz at the University of Cologne, is yet to be published. He did publish the results of a 2-year study in which pupae were exposed to 120 hours at an intensity of 10 μW/cm² and a frequency of 40 GHz (Nimtz, 1983). A few hours after becoming adults, one female and two males were crossed to start a family. Up to 15 such families were started from both control and experimental groups, and their offspring were counted. The number of offspring in the first generation represented the fertility of the parent (P) generation. The fertility of two successive generations, $F_1$ and $F_2$, were similarly determined. Analysis of the results led to the conclusion that the fertility of the P generation was strongly enhanced in the exposed insects, while their offspring appeared not to be affected. The fertility of the "grandchildren," the $F_2$ generation, appeared to drop by about 10 percent compared with the controls.

After completing two additional experiments under the same conditions, Nimtz recompiled and reanalyzed his data. Applying more rigorous and revealing statistical tests, he found, in fact, that in this series of six experiments with over 82,900 flies, millimeter-waves had no apparent effect. One of the major reasons for the ultimate conclusion had to do with the extreme variability in the number of offspring per family--under all experimental conditions. The observed range was from 0 to 669 for one family. In fact, of 360 families, 13.3 percent had no offspring at all and 18 percent had between 0 and 50 offspring. On the other end of the spectrum, 4.4 percent of the families had between 551 and 669 offspring. There were several other analytical and statistical anomalies that a less careful and less astute investigator than Nimtz might have overlooked in the zeal to find a result. As mentioned earlier, these new findings, which negate the previous ones, will be published soon.

Other Experiments

Several research groups have chased resonant effects in *E. coli*. (S. Motzkin [Polytechnic Institute of New York] discussed this at the symposium; see also Motzkin et al., 1983; Blackman et al., 1975; and Swicord et al, 1978). The researchers have used as indicators such things as production of colicin, changes in mitochrondrial calcium transport, and adenosine triphosphate (ATP) production in oxidative phosphorylation. To date, no one has found significant modification of any of these cellular processes at exposure levels that did not cause major temperature excursions. On the other hand, Poglitsch (MPIF, Stuttgart), who has been studying the growth rate of cress roots at 56 GHz, said at the meeting that he has found a decline in this rate at exposure levels as low as 1 mW/cm². Most important, he observed that the effect was highly dependent on the polarization of the field and not to an induced temperature increase. The greatest effect occurred when the E-field was parallel to the long axis of the root. At the symposium, O. Gandhi (University of Utah) said that this may be an antenna effect due to the shape of the root. A paper on this research has been submitted for publication.

Yet another interesting example of a nonthermal, frequency-specific effect of millimeter-waves has been found by the group at MPIF headed by Kremer. At the meeting Kremer commented that when his researchers swept frequencies in the range between 64.1 and 69.1 GHz and used stabilized frequencies of 67.200 ±0.001 and 68.200 ±0.001 GHz (power densities <<5 mW/cm²), they observed a reduction in the size of the puffing of giant chromosomes of the midge *Acricotopus lucidus* (see also Kremer et al., 1983). While this experiment is too involved to address adequately here, it should be pointed out that the puffing phenomenon is a highly complex process that does not depend solely on transcriptional activity--i.e., enzymatic activity of RNA polymerases. The process comprises interactions between transcription, RNA-processing, packaging of RNA with distinct nuclear proteins and storage or transport of ribonucleoprotein-products. It was concluded that the coherence of the radiant energy is decisive in causing the effects because the photon energy (about $2.9\times10^{-4}$ eV) of millimeter-waves is less than 1/200 of the thermal energy kT. It was further concluded that the observed effects might be explained by Fröhlich's theories of coherent electric vibrations in biological macromolecules--i.e., the externally

applied radiation field influences the excitations within the biological system.

One point made by Kremer et al. (1983) may be questioned by some. One of their conclusions was that their "result could be of importance in the discussion of safety standards with regard to possible hazards from millimeter wave radiation." This conclusion was reached because their exposure levels were below the safety standards of most European countries and the US. However, it must be remembered that at millimeter-wave frequencies, absorption of energy by genetically important material is essentially precluded due to the very shallow depth of penetration.

## What Has Been Learned

Collectively, those working with millimeter-wave effects seem to agree that there are more than the usual number of experimental pitfalls in the research at these high frequencies. Gandhi suggested at the symposium that all well-designed systems should: (1) be broad banded and tunable, in order to look for frequency effects; (2) possess high coupling to the sample; and (3) have good frequency control and, above all, good stability. The need to provide a good heat sink is absolutely essential when studying cellular and other preparations at millimeter-wave frequencies. The leading investigators are now using several materials as heat sinks in fabricating their sample chambers; gold, sapphire, glass, and quartz are good choices. Since temperature measurement is more difficult at these wavelengths due to the physical size of the sample containers, one must often devise exotic methods to measure the temperature in real time. Interested readers are urged to examine the laser interferometric technique outlined by Grundler et al. (1983). It is absolutely essential to know the fundamental temperature response of the system under study, and the temperature profile and effectiveness of the heat sink during the course of the exposure.

Finally, at the symposium Kremer provided a few more important "do's" and one "don't." Do:

- Conduct sham-exposure experiments (not simply "controls")
- Carry out the experiments blindly
- Look for a frequency dependence
- Look for a power dependence
- Simulate the microwave-induced temperature increase.

Then, don't forget that a nonthermal bioeffect is an utterly remarkable phenomenon.

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*12/14/83*

## COMPUTER SCIENCES

### DESIGN OF A MULTIPROCESSOR RELATIONAL DATA-BASE SYSTEM

*by J.F. Blackburn. Dr. Blackburn is the Liaison Scientist for Computer Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the National Academy of Sciences, where he is Executive Director, Computer Sciences Board.*

The Institut National de Recherche en Informatique et en Automatique (INRIA, Le Chesnay, France) has developed a first-generation, portable, data-management system. The Système d'Accès à des Bases Relationelles (SABRE) is now operational; it is designed for a multi-microprocessor configuration and is based on a relational model (Gardarin et al., 1983). SABRE is a software-oriented system; this means that most of the data-base management functions are done in software, although a small amount of special-purpose hardware may be used.

The principal aim of the SABRE project is to improve the performance and functions of systems that manage large relational data bases. The control concepts employed are parallelism, filtering of data, cache memory, multidimensional clustering of data, and concurrent execution of transactions. In order to be portable, the system is written in Pascal language.

The objectives of the SABRE project are:

1. To develop an extensible and portable French relational data-base manager where data are viewed as tables and which will be a basic tool to build integrated data-base systems and distributed data-base systems.
2. To improve response time in comparison with existing relational data-base systems. This will include investigation of parallelism, reduction of input-output time, and the management of efficient access paths to relations.
3. To allow various views of the data base to be defined and queried by different groups of users.
4. To guarantee data-base integrity when data are updated simultaneously by concurrent transactions or when erroneous updates occur.
5. To obtain a slow degradation of system performance without loss of function when a component of the system fails.

#### Functional Architecture of SABRE

The functional architecture of SABRE is composed of a set of successive layers from the user to the disk units; each layer manipulates successively simpler objects.

The user interface is supplied by the first layer. Its role is to enter the queries or updates on a data-base view, then to pass the requests and send them to the next layer. (A view is a set of relations which may be derived from existing relations and is associated with a group of end-users having rights on certain relations in the view). The first layer also presents results to the user. The external language is flexible and provides the user several types of queries similar, for example, to Structured Query Language, introduced by IBM.

The next layer of the functional architecture manages the views. It mainly maps requests on views into requests on relations of one or more underlying bases. This layer also performs authorization checking and integrity controls. The external interface of this layer is the data manipulation protocol.

The base layer receives requests on base relations, transforms them into a tree of extended relational algebra operations, and performs the optimization of this tree. The tree leading to the minimum input-output time is selected. The relational algebra operations of the chosen tree are requested by the subsequent layer.

The relation layer performs algebra operations on relations. It manages access paths to relations in order to determine the parts of one or two relations which must be accessed to perform single or binary operations. The other task of this layer is to perform some specific functions on parts of relations, mainly the join or sort operations.

Tuples, collections of related elements, are stored inside associative partitions generally of the size of a disk track. The addressing inside a partition is done by content using

Boolean expressions. (A Boolean expression is composed of elementary predicates involving alpha-numerical or textual data.) The partition layer performs the selections on a list of partitions identified by a logical address. It also performs insertions of new tuples in a partition and deletions of selected tuples. And it provides concurrency control and commitment of updates at the end of a transaction.

The INRIA researchers introduced parallelism in the query execution in a vertical manner by assigning a different processor to each layer, and in a horizontal manner by assigning several processors to each layer.

Operational Architectures of SABRE

The SABRE machine is composed of the following:

- The view and integrity processor works on a data-base view. Its role is first to translate the request expressed on virtual relations described in the view into a request expressed on real relations implemented on disks. Another role is to perform some integrity control at each update.
- The authorization control process controls the user's rights on the views.
- The request evaluation processor works on a set of implemented relations (a real data base) and performs the request decomposition and optimization.
- The relation access processor (RAP) works on an implemented relation and manages access paths. When an insertion of tuples is performed, the RAP determines the partitions where the tuples are to be inserted, and manages the predicate trees associated with relations. When a restriction is performed, the RAP determines which partitions should be scanned.
- The join, sort, and aggregate processors perform join, sort, and compute aggregate functions on partitions.
- The concurrency control and recovery processor is responsible for allocating secondary and cache memories. It also replaces cache memory pages into partitions when the cache memory is saturated.
- The filtering processor performs selection, insertion, and deletion of tuples in a partition.

A real operational architecture is associated with each version of SABRE. It is composed of one or more real processors supporting a set of virtual processors. Two generations of SABRE are being implemented. In the first generation, all the virtual processors are implemented on one real processor. This system is currently working with the operating system MULTICS at INRIA. All the virtual processors are written in Pascal, and are easily transportable to other systems.

The second generation is a true multi-microprocessor data-base computer. It will include three parallel processors, and two users will be able to operate it simultaneously in the first version. The software will be the same as in the first generation's system. Implementation of this version is under way.

The hardware to be used in the second generation SABRE has been developed by the French Centre National d'Etudes des Telecommunications and is called SM90. It is composed of three Motorola 68000's and an input-output processor. Each 68000 will run the UNIX operating system, and each can address a private memory, a local memory, and a common memory through mapping facilities.

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*11/17/83*

## FRENCH DEVELOP PLANS FOR FIFTH GENERATION COMPUTING SYSTEMS

*by J.F. Blackburn.*

During the Fifth Generation World Conference--held in London from 27 through 29 September 1983--Jean-Claude Rault (Agency for Information Technology, France) gave a report on relevant current work and French plans for developing fifth generation computing systems. (For other articles about this conference, see *ESN* 37-12 and 38-1.) The First International Conference on Fifth Generation Computing Systems had been held in Tokyo from 19 through 22 October 1981. Computer scientists in Japan announced the design of a 10-year research plan to develop prototypes of new computing systems to meet the needs of society in the 1990s. These systems

must be easy to use, flexible in application, and very fast. Application programs using sophisticated techniques of artificial intelligence would enable the machine to receive and process natural language and even perform translation from one language to another. The computer systems would be made up of communicating machines with special processing functions, including handling relational data bases and performing logical inferences. To perform efficiently, each machine would be made up of many processors operating in parallel.

Although there is no overall plan in France that corresponds exactly to Japan's, parts of the French effort correspond to the Japanese program. In his report, Rault differentiated between existing research under the management of the Centre National de Recherche Scientifique (CNRS) and the National Projects Concept, which came into use in mid-1982 as a direct result of the Japanese Fifth Generation Computer Program. Therefore, we will first discuss the CNRS programs that existed before mid-1982 and then national projects. There is some overlap between them.

CNRS Programs

The main funding sources for the CNRS programs are:

- The Ministry of Industry and Research, including its Research and Technology Budget and Agence National pour la Valorization de la Recherche (ANVAR).
- French Telecom, including Centre National d'Etudes de Telecommunication (CNET).
- Agence de l'Informatique.
- The Ministry of Defense, including Direction de Recherche d'Etude et Technique (DRET), somewhat similar to the Defense Advanced Research Projects Agency (DARPA) in the US.

The Groupe de Recherche Coördonné (GRECO) is made up of cooperative groups under the management of CNRS. This group coordinates advanced research in computer science. The participants in the GRECO program are the CNRS laboratories, CNET, Institut National de Recherche en Informatique et en Automatique (INRIA), Institut de Recherche en Informatique et Systèmes Aleatoire (IRISA), and the following universities: Paris 6, 7, 8, and 11; Grenoble; Nancy; Rennes; Toulouse; Bordeaux; Poitiers; Metz; and Strasbourg. Also, several industrial firms have research and development programs that are a part of the CNRS program: Compagnie Bull, Compagnie General Electrique (CGE), and Thompson-CSF.

In GRECO the main research topics that are relevant to fifth generation computing are languages, translations, specifications, proof of correctness, and transformations. Among the readily available tools are a Digital Equipment Corporation VAX system in Bordeaux running the operating system MULTICS, and an SM90 multiprocessor system open to research groups. The SM90 system uses Motorola 68000 microprocessors as components. The coordinator is R. Cori of the University of Bordeaux.

GRECO "PAROLE" is a speech synthesis and recognition program, coordinated by J.-P. Hatton (University of Nancy). GRECO "Calcul Formel" is a program of research on symbolic manipulation coordinated by D. Lazard (University of Poitiers). GRECO $C^3$ is a military program on communication, cooperation, and control coordinated by Messers G. Roucairol and M. Nivat in the Ministry of Defense. A program on advanced robotics is coordinated by G. Giralt, Laboratoire d'Automatique et d'Analyse des Systemes (LAAS, Toulouse) and includes participation from many other CNRS locations (see *ESN* 36-11, 37-1, 37-3, and 37-5).

Other CNRS programs include a data-base management system for third generation computers. This effort deals with new applications and functions and is done in collaboration with CGE and Comptoir d'Etudes Radio Techniques. Relational data bases are not properly organized to handle varied information such as graphics and documents. A project to identify the needs of data bases for these new applications began in January 1982. CNRS has had an artificial intelligence program since 1979. Its application in robotics is under way at INRIA, LAAS, Laboratoire d'Informatique pour Mechanique et les Sciences de l'Ingenieur (LIMSI), and IRISA (*ESN* 36-11, 37-1, 37-3, and 37-5). The use of artificial intelligence in designing programming languages--including logic and functional programming--is especially active at INRIA, Rocquencourt.

National Projects

The *filières* (sector) concept was initiated in May 1981; the objective was to leave no areas uncovered in the French research and development program. The *filières* cover vertical chains of production from raw materials to finished products in sectors including energy, biotechnology, and electronics. The government attempts to coordinate the

overall technical direction of the *filières* by promoting joint research activities linking industry with large research organizations and universities. Since mid-1982 the National Projects concept has been used. During the first half of 1983, specifications and plans were made and a request for proposals was issued. Assessments of the responses were completed in the spring of 1983, and recommendations on awarding contracts were made. However, as of 1 November 1983 the recommendations had not been made public. It is nevertheless expected that there will be national projects in computer-aided design for very large scale integration, design and computer-aided manufacturing, software engineering (including a new version of ALGOL), computer-assisted translation, a hardware display system, minicomputers and work stations, computer-assisted instruction, a supercomputer (for the military, no details are available), and home electronics.

Thus far, the following themes of national projects have been defined:

1. Man-machine interface research
   a. Natural languages
   b. Speech recognition and synthesis
   c. Vision
2. Intelligent knowledge-based systems
   a. Knowledge representation
   b. Reasoning
   c. Proof techniques
   d. Knowledge-based management systems
   e. Expert systems
3. Basic tools and techniques
   a. Languages (PROLOG, LISP, functional programming)
   b. Engineering of artificial intelligence software
   c. Specialized processors

About 150 professionals from academia and public research are involved in the national projects; about 60 professionals from industry are participating. Rault said these figures represent a conservative estimate of the actual numbers. More than 20 companies will participate in national projects. Also, more than a dozen departments of the government and about a dozen universities will be involved.

The French program is indeed comprehensive; like the British Alvey Program (*ESN* 37-12:447-450 [1983]) and the German program (*ESN* 38-1:17-18 [1984]) the French program is complementary to the EEC program, ESPRIT (*ESN* 38-2:69-71 [1984]).

*11/7/83*

## PROGRESS TOWARD REAL-TIME DISTRIBUTED COMPUTING

*by J.F. Blackburn.*

A project called SIRIUS was established in 1977 at the Institut National de Recherche en Informatique et en Automatique (INRIA, Rocquencourt, France) to design programming systems to manage distributed data bases. The objectives were: (1) to set up research on distributed data management in French universities, (2) to promote knowledge of the domain within the computer industry and among potential users, and (3) to design prototypes of distributed data-base management systems (DDBMS) that would be sufficiently operational for pre-industrial or research and development use.

By 1981, French universities--in response to proposals from INRIA--had developed six prototype DDBMs. Beginning in 1979, work increased at INRIA; the main pre-industrial prototype developed there was the SIRIUS-DELTA system. SIRIUS-DELTA has the following features: the user is not aware of the data distribution; various types of data distribution can be processed; the system is reliable, and heterogeneity in hardware and software is allowed. The prototype SIRIUS-DELTA is operational and has proven the feasibility of the approach taken. Such systems should be useful for many applications.

Following the development of SIRIUS-DELTA, INRIA designed a system to implement a multi-data-base approach. Any data base is defined according to some data model. For example, the relational data model considers that a data base is a set of relations. Other models may consider that elements of a data base are record types, entity types, or components. The implicit principle of all these data models is that the elements of a data base are not themselves data bases. A data base constituted from such elements may be called a logically centralized data base or a single data base. A multi-data base is a set of data bases or of multi-data bases having the following properties: (1) language to express manipulation of data that are not within the same data base; (2) a language to define data within the multi-data base and its structure and the dependencies between data bases and multi-data bases.

The fundamental principle of the SIRIUS-DELTA approach is that a universe or collection of related elements of information is modeled with a single data base, whether distributed or not.

These cannot be data that model some universe and are in more than one data base.

The fundamental principle of the multi-data-base approach is that a universe is typically modeled with several data bases. Some of the data bases model sub-universes that are rather distinct--e.g., a universe of cinemas or a universe of restaurants. Others may model differently the same universe--e.g., different restaurant guides. Some data bases may be derived from others--also including data on their own.

In a logically centralized data base, the user considers the data base that he manipulates to be a single data base, and he is not concerned about whether it is distributed. However, the general case should be one in which the user knows that he manipulates several data bases. The goal of the multi-data-base approach is to make these manipulations easy. The specific goals are the following:

1. One should include all the possibilities that may result from the concept of a distributed data management system (DDMS), extended to the case of a collection of data bases.
2. Multi-data-base manipulations should be expressible in a data manipulation language. The goal of this language should be one assertion (command) per manipulation.
3. One should be able to formulate constraints preserving integrity and privacy of data that are not within the same data base.

At INRIA two versions of distributed data management have been developed in the SIRIUS-DELTA and in the multi-data-base approaches. The former provides tools to constitute and manage a single data base, while the latter provides tools to constitute and manage a multi-data base. Prototypes have been developed that prove the feasibility of both approaches.

According to Gerard Le Lann, head of the distributed computing project, the next logical step at INRIA was to introduce the concept of real-time distributed computing systems. Such a system controls (via actuators) and monitors (via sensors) a physical process that is governed by a given set of internal laws. These laws, which define the behavior of the physical process, are functions of physical time. It is assumed that the evaluation of the physical process attributes such as temperature, color, and volume can be determined. The purpose of controlling and monitoring the evaluation of these attributes is to constrain them to take their values in a specific domain so that the resulting overall physical process has specific properties. This should mean that it behaves as expected in agreement with some specifications. Restricting acceptable values to a specific domain usually is a well-perceived necessity for all possible attributes except time.

Some examples of real-time applications are: (1) flexible manufacturing, where each manufacturing machine can be adapted instantaneously to continuously changing working conditions; and (2) automatic flight control which will maintain aerodynamic stability and reduce peak local pressure loads on an aircraft's structure by controlling the surface of the aircraft body and wings--i.e., automatic manipulation of flaps and rudders.

Modeling of a real-time application requires enumeration of the objects which are part of the physical process, description of the set of states that can be taken by each object, and enumeration of operations that cause objects to change state. An object has a design interface with the external environment, defined by its sets of possible states and associated operations. A protocol enforces legal sequences only--that is, operations causing state changes which express the invariant properties to be satisfied by the object.

The interactions that non-real-time computing systems have with the social or physical process with which they are interfaced are logical, partial, and recoverable; most control functions are implemented outside the systems. On the other hand, the interactions a real-time system has with an external physical process are physical, global, and not transparently recoverable; most control systems are implemented inside the system. Clearly, a real-time system has to perform a number of tasks under specific timing constraints; furthermore, a real-time system must produce only accurate output states. Other characteristics of a real-time system include high reliability, and availability and flexibility in function, implementation, geography, and computation.

A real-time computing system should produce good output when given good input and should be able to isolate exceptions and catastrophes in one system from others operating concurrently. This is called atomicity. Maintaining the atomicity of concurrently executing operations requires some form of synchronization. If assumptions about

factors such as operation durations and frequencies can be made and reflected safely and accurately in an implementation, physical time can be used. This approach may conflict with requirements for reliability, availability, and flexibility. Another approach is to ensure that operations are mutually exclusive through some centralized or distributed algorithm. At INRIA the assumption has been made that atomic operations are obtained out of sub-operations that are themselves atomic.

On the subject of real-time communications, Le Lann commented that the assumption made was that resources needed by the various processes were available. Real-time communications require that a destination buffer, or computing cycle availability, or both, are always present. Destination scheduling is largely neglected or superficially examined in many systems. Designers of real-time communication systems have quite a different problem from that of, for example, designers of public telecommunication systems. Real-time communications cannot be achieved by protocols ordinarily designed for wide or local area networks. For example, resource management at some destination which communicates with a number of message sources is under the control of the sources in a real-time system and is not the sole responsibility of the destination. This affects the nature of the protocols needed. With real-time applications one is dealing with distributed computing systems, not with networks of more or less autonomous computers.

There is a debate about whether carrier-sense multiple access (CSMA) protocols or token-passing (TP) protocols are best suited for real-time communications. CSMA algorithms are designed to prohibit transmissions, if necessary, to reduce the number of collisions, not guaranteeing that every message eventually gets transmitted. CSMA protocols usually are considered nondeterministic, whereas TP protocols are considered deterministic, (determinism means guaranteed promptness). However, promptness requirements must be quantified. INRIA has developed a multiple access protocol which is described fully by Le Lann (1983).

INRIA'S three projects described here represent major steps forward in the development of real-time distributed computing. The first two, SIRIUS-DELTA and the multi-data base approaches, have been fully implemented in pre-industrial or laboratory form--showing the feasibility of the approaches taken. The third, a real-time system, is being implemented at INRIA.

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*11/10/83*

## MATERIAL SCIENCES

### DISLOCATIONS AND ELECTRON MICROSCOPY AT THE UNIVERSITY OF OSLO

*by R.W. Armstrong. Dr. Armstrong, formerly at ONR, London, is on sabbatical leave from the University of Maryland for the 1984 spring term as Visiting Fellow, Clare Hall, University of Cambridge, UK.*

Prof. Jens Lothe is pursuing research on dislocation theory and Prof. Jon Gjønnes is working on electron microscopy at the Institute of Physics, University of Oslo, Blindern, Oslo 3, Norway. The electron microscopy research is connected also with activities at the Central Institute of Industrial Research, nearby in Blindern.

Lothe's research interests include anisotropic elasticity theory for dislocation properties and surface waves on solids. Belov, Chamrov, Indenbom, and Lothe (1983) have determined the elastic field equations for a straight dislocation line piercing the interface of an anisotropic bicrystal. The formulas are proposed to be amenable to numerical calculations for real bicrystal results. Alshits and Lothe (1981) have extended earlier work done by Lothe and D.M. Barnett (Department of Materials Science and Engineering, Stanford University, Stanford, CA 94305) on the existence and formalism for describing subsonic surface waves in piezoelectric crystals. The newer work covers theoretical aspects of reflection phenomena and "leaky" surface waves in the first transsonic range of velocities.

Lothe has completed with Prof. John P. Hirth (Department of Metallurgical Engineering, Ohio State University) the second edition of their book *Theory of Dislocations* (John Wiley and Sons

Publishers, New York, 1982). The very creditable job was done with support provided by the US National Science Foundation, the US Office of Naval Research, and the Norwegian Council for Industrial and Scientific Research. With V.L. Indenbom (Institute of Crystallography, Leningrad 194021, USSR), Lothe is now contributing to and co-editing another book: *Elastic Strain Fields and Dislocation Mobility* (North Holland Publishers, Amsterdam, 1984). Some chapter titles are: "Uniformly Moving Dislocations, Surface Waves"; "Dislocations Interacting with Surfaces, Interfaces or Cracks"; and "Dislocation Motion over the Peierls Barrier." This book is to appear in the series Modern Problems in Solid State Physics, co-edited by A. Maraduden (Department of Physics, University of California, Irvine CA 92717) and V.M. Agranovich (Institute of Spectroscopy, USSR Academy of Science, Troitsk, Moscow 142092).

Gjønnes has been involved over the years in a wide assortment of transmission electron microscopy (TEM) studies, ranging from basic atomic scattering phenomena in semiconductors to current interest in weld-cracking of steels and the microstructures of rapidly solidified Mg-2%Mn metal alloys. The Institute of Physics has a JEM 200CX electron microscope, which is operated as a central facility for various research projects in other institutes.

Gjønnes has spent study periods in the physics departments at the University of Melbourne (Australia) and Tohoku University (Sendai Japan). His early work involved, for example, structure factor determinations for Si and GaAs by an intersecting-Kikuchi-line method that he invented at Oslo with R. Høier and carried to the 1.0-MeV microscope laboratory at Tohoku University. Other work has included electron channelling effects associated with induced x-ray emission from diatomic ZnS, ZnSe, and $FeS_2$ crystals (with J. Taftø); diffuse scattering in dark field images of Cu precipitates in Si (with J.K. Solberg); and the TEM observation of Cu precipitate-dragging by dislocations climbing in Si crystals. Gjønnes has contributed a chapter on structure determination by electron diffraction to the book: *50 Years of Electron Diffraction* (Reidel Publishers, Berlin, 1981), edited by P. Goodman.

In cooperation with B. Gylseth (Institute of Occupational Health, Oslo, Norway) and O. Bjørseth and Ø. Dugstad (Norwegian Institute of Technology, Trondheim), a TEM study was done to identify $NaAlF_4$ fibrous particles (in the range of 0.027 to 0.114-μm diameter and 0.23- to 9.71-μm length) occurring in "pot-rooms" during the production of primary aluminum from reacted alumina and cryolite. Another cooperative project involved H. Herø and R. Jørgensen (Scandinavian Institute of Dental Materials, Oslo), E. Sørbrøden (Institute of Physics, University of Oslo) and E. Suoninen (University of Turku, Finland) on revealing extremely fine microstructures of face-centered tetragonal rod-like particles of about 0.05-μm diameter indicated to be PdCu in a dental Ag-Pd-Cu-Au alloy.

With B. Andersson and A.R. Forouhi, Gjønnes did a TEM study of the ordering of interstitial-metal vacancy tetrahedron defect clusters in oxygen-rich vanadium monoxide as compared with the ordering of {111} oxygen vacancy sheets in the substoichiometric oxide. The 1.0-MeV Japan Electron Optics Laboratory Co. electron microscope at the Swedish Institute for Metal Research was used for the study. Andersson is now manager of metalworking and physical metallurgy at the Central Institute for Industrial Research, Oslo 3. H. Mathiesen, J.E. Tibballs, and Andersson (1983) have reported preliminary results on the mechanical properties of a Norsk Hydro 303 aluminum alloy containing 1.23 (weight percent) Mn-0.59Fe-0.25Si-0.24Mg-0.01Cu subjected to various processing and intermediate annealing treatments. In addition to the reported variations in particle volume fraction, particle size, and grain size in the AlMn(Mg) alloy, consideration is being given now to the importance of particle spacing in determining dislocation subcell structures within the material and consequent strength properties. The work is being supported by agencies with interests in Norwegian aluminum: the Royal Norwegian Council for Scientific and Industrial Research; Mosel Aluminium; Lista Aluminiumsverk; Norsk Hydro, Karmøy; and ÅSV-Nordisk Aluminium.

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*12/9/83*

## EDUCATION AND RESEARCH AT UNIVERSITÄT GESAMTHOCHSCHULE, SIEGEN

*by R.W. Armstrong.*

This article covers a visit spent with Prof. Dr.-Ing. K. Detert, Institut für Werkstoffkunde, currently Dean of the Institute des Fachbereichs Machinentechnik, Universität Gesamthochschule, Siegen. In addition to materials science and engineering, six other university institutes--mechanics and controls, construction, fluids and thermodynamics, manufacturing, energy, and systems engineering--are included under the dean's responsibilities. Universität Gesamthochschule is a relatively new institution, founded in 1970.

### Education

The combined engineering institutes have 800 students in a rather new type of integrated curriculum that began in 1974. A Y-model path was developed at that time to accommodate more students along a branched course leading either to a practical or an academic diploma. Previously, about 5 percent of students in the nation would enter the university system and obtain an academically oriented engineering diploma after 4 years of study. The model system was proposed to lead eventually to perhaps 25 to 30 percent of potential students in the nation being able to obtain a university diploma.

In the Y-model for engineering at Siegen, the first 2 years (or four semesters) are common for both degree paths, except for a few courses. At the beginning of the third year, the student may choose to spend another 1½ years on a practically oriented diploma of engineering (diploma I), or another 2½ years--the previous standard period--on an academically oriented diploma II. It was imagined that about one-third of the students would proceed along the traditional route II and two-thirds along route I for engineering practice. Experience has produced reversed student numbers along the two branches, and this is straining university resources.

Detert has the impression that most engineering students among the greater number now accepted want to follow the traditional diploma path mostly because they perceive the financial rewards will be greater upon graduation--even extending to increased rewards after further graduate work. The students apparently are unsure about available jobs and job rewards for the diploma I path. Not enough graduates have been produced nor has an established record of employment been achieved to make route I as attractive as the planners wanted. To some extent, routes I and II might be matched with bachelor's and master's degree levels of achievement, respectively, in the US universities--particularly when one considers that German students spend 13 years in primary and secondary school before entering the university, generally at the age of 19. Interestingly enough, the job situation in the US is completely reversed--the job market there is so favorable for bachelor's degree graduates that most graduate engineering programs necessarily contain a large number of foreign students in order to have viable courses, and especially to sustain on-going research programs.

### Research

Detert, H. Kanbach, M. Pohl, and E. Schmidtmann (1982) have investigated the hot tensile test, creep, and simulated weld properties of CrNi austenitic steels alloyed with N, Mo, Mn, Nb, Ti, and/or V. Excellent electron microscopy results were reported. Detert and Kanbach (1983) have followed up the work with a later report relating the weld properties to the composition-dependent transformation structures obtained in the different alloy systems. With R. Scheffel, U. Mittag, and K. Stünkel, Detert has been studying fatigue crack growth in fracture mechanics testing of AlMgSi1 alloy (containing about 1.0 weight percent each of Mg and Si). The hysteresis behavior of the applied mode I cyclic stress intensity ($\Delta K$) is being matched with microscopic surface observations of the crack closure behavior. An example of partially closed crack faces is shown in Figure 1. Grain-size effects are indicated to be important for the alloy.

Besides Detert, J. Kurzeja and K.H. Zum Gahr are professors in the Institute of Materials Science. Kurzeja is head of the institute and is interested in thermomechanical working of steels to

Figure 1. Partially closed crack in AlMgSil alloy showing several regions of contact between the matching faces.

achieve optimum properties for practical uses such as offshore engineering structures. At Ruhr-Universität Bochum, Zum Gahr had previously done direct electron microscope observations of crack propagation in thin metal foils of FeNiAl and AlZnMg1 alloys and had investigated the Hall-Petch grain-size dependence of the yield stress, fracture stress and elongation to fracture of an Fe-36 (atomic *percent*) Ni-12Al precipitation-hardenable austenitic steel. With C. Verpoort at Bochum, Zum Gahr measured fatigue crack growth rates for the same austenitic steel material at different grain sizes. It was found from scanning and transmission electron microscopy observations that the varying microstructures of precipitates at grain boundaries in differently treated specimens had a controlling influence on the resultant fatigue cracking.

Zum Gahr is currently concerned with the abrasive wear behavior of materials--particularly ductile metals. He has summarized experimental results obtained on the wear properties of pure metals and alloys, including amorphous $Fe_{40}Ni_{40}P_{14}B_6$ and $Fe_{40}Ni_{38}Mo_4B_{18}$ "Metglas" and $Fe_{78}Mo_2B_{20}$ materials (Zum Gahr, 1982). Previous work dealt with a comparison of the pin abrasion test wear properties of the metallic glasses in the amorphous state and when partially or almost completely crystallized (Zum Gahr and Nöcker, 1981). Lower abrasive wear resistance than expected on the basis of their hardness properties was found for the amorphous materials. The later work has dealt with analyzing wear properties in terms of the material's work-hardening, ductility, homogeneity of strain distribution, crystal anisotropy, and mechanical instability. Excellent scanning electron microscopy observations have been made of hard-particle gouging or continuous filaments produced by micro-machining during abrasive wear. Tapered sections of wear tracks have been metallographically polished and etched in 70-30 brass to show the extent of localized deformation. Deformation was measured by using a recrystallization method. The effect of polycrystal grain size on wear properties is being investigated.

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*12/12/83*

# OCEAN SCIENCES

## THE GEOLOGY AND BIOLOGY OF CORAL REEFS

*By Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.*

The International Society for Coral Reef Studies was formed in 1979 by a small group of reef specialists led by Dr. David Stoddard of Cambridge University. The Society held its third annual meeting from 8 through 10 December 1983 in Nice, France. About 80 people attended the conference (four from the US); roughly two-thirds were biologists, and one-third were geologists. The Society began publishing its own refereed journal, *Coral Reefs*, in 1982--it's a Springer-Verlag publication. The membership fee, including *Coral Reefs* and the society's *Newsletter*, is $50 or £30 (a bargain at today's exchange rates).

The program at Nice consisted of simultaneous sessions of papers on geology and biology of coral reefs. I attended most of the biology papers and a few of the geology sessions. My overall impression of the state of the art of coral research, based on the papers presented, is that it is still mostly an observational or descriptive science. This is not to suggest that the papers were not interesting or important, but rather that only two of the 50 or so papers set out a clear design for laboratory or field work, followed by a discussion of the data analyses and results. The data sets are for the most part, relatively small and usually seasonal. I did hear that the Australian reef specialists are using a wide range of analytical methods in analyzing data for the Great Barrier.

It's also my impression from casual conversations at the meeting that institutional support for reef research is modest, so that the reef specialists spend a great deal of their time locating funding for field trips and in carrying out the field work. One other general observation: few of the coral biologists and geologists investigate reefs as large-scale biophysical systems. The scale of the research is mostly detailed site-level, resulting in few overall generalizations. Not a single investigation summarized at the meeting used remote sensing data; and the one paper that did described the potential application of remote sensing generated little discussion. There was talk in the halls of a forthcoming paper that includes a "computer model of a coral reef," but I was unable to find specifics.

The theme that I found most interesting among the papers was "what's happening to the world's reefs?" In the Middle East and along the coast of Africa and Southeast Asia the answer to this question is rather simple--we're killing them at an alarming rate. The methods of extermination range from massive siltation associated with land clearing (especially of rain forests) to physical destruction as a by-product of Africans using dynamite for fishing. Among the most alarming and seemingly unnecessary is the widespread oil pollution in the Red Sea and Persian Gulf. Apparently the environmental controls in the Middle East are modest, at best. Therefore, oil spills are common, and dredging and construction projects pay little heed to the fact that some of the most productive coral reef systems in the world fringe those water bodies. There are, of course, exceptions--but few it seems. Oil production is the highest priority.

The other puzzling fact that reappeared throughout the 3-day meeting was evidence of widespread disease among the coral reefs of the world. Three diseases, in particular, were reported from sites throughout the tropical seas. The most prevalent is "bleaching": the coral simply dies over a relatively short period of time, leaving behind coral forms that look as if they have been bleached dead white with chemicals. All species seem to be affected, including atolls, fringing reefs, and barrier reefs. In some areas 60 to 80 percent of the reefs have died. Some investigators believe siltation is the problem, yet the same disease is reported on remote Pacific islands where there is no construction. Also, bleaching doesn't seem to occur below a water depth of 25 m. The society has decided to look into the distribution of bleaching and report the results in their *Newsletter*.

Equally puzzling are the two "band diseases," or plagues. Black-band disease is a coral killer that occurs in most tropical waters. It has been definitely associated with a new species of blue-green algae that thrives on reefs. How long it will spread and how soon the reefs will recover are unanswered questions.

White-band disease is sweeping through the coral reefs of the Caribbean

and South America. Biologists don't know what's causing this plague--unlike the situation with black band. In white band a small (2-cm wide) band of diseased coral forms as a ring around the coral structure. The branching corals, such as staghorn and elk horn, seem particularly susceptible. White band feeds on or dissolves the coral colony, leaving behind a dead grey-white skeleton that is easily destroyed by waves. In the Virgin Islands, for example, as much as 80 percent of the branching corals have been destroyed by white-band disease.

The geologists tend to believe the problem is related to the biology of the reefs, perhaps an exotic virus. The biologists think it may be related to sediment or pollution, but none are certain. In a few cases recovery is under way, though it is not widespread. If the branching corals make a general recovery, the reefs will progress rapidly because some species grow at rates of up to 10 cm a year.

Finally, I was impressed with a presentation made by M.L. Harmelin-Viven (Station Marine d' Endoume, Marseille) on the impact of Pacific hurricanes on the reefs of Tikehau Island, French Polynesia. In this case the investigator had the good fortune of having inventoried and photographed the reefs a few months before the storms struck. On outer reef slopes coral destruction, varying from 50 to 100 percent, was a function of depth. Upper-slope coral communities composed of small colonies well adapted to high-energy-level environments suffered less. Coral destruction was spectacular at depths above 12 m, 60 percent between 12 m and 30 m, and 100 percent beyond 35 m; earlier living coral coverage ranged from 60 to 75 percent. The outer slope was transformed into a "scree" zone covered with coarse sand and dead coral rubble.

The return interval for hurricanes of major magnitude in this part of the Pacific is about once every 100 years, so periodic destruction doesn't seem to result in permanent damage to the coral system. The reefs fully recover from these pulses of energy. However, this is not unusual in natural systems; for example, forest fires are now considered beneficial by most ecologists, and frequent storm surges along the low-lying Atlantic Coast barrier islands provide beneficial stress to the coastal ecosystems.

My overall impression is that the International Society for Coral Reef Studies is made up of a small, dedicated, and enthusiastic group of biophysical scientists. It was refreshing to hear open discussions among geologists, biologists, and oceanographers. Cooperation and data exchange were the rule, not the exception. This may be a product of tight budgets; but whatever the reason, it seems to be contributing to important interdisciplinary research. The 1985 meeting of the society will be held in Miami, Florida, in early winter, and in Tahiti in the summer of 1985 (they work in exotic places). Anyone interested in future meetings or membership should contact P. Spencer Davies, Department of Zoology, University of Glasgow, Glasgow G12 800, Scotland.

*12/14/83*

## OIL SPILLS: CAN SONAR HELP INVESTIGATORS?

*By Chester McKinney. Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from The University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.*

In the spring of 1980 I visited the office of the French navy at Brest which is responsible for the preparation of shallow-water, ocean-bottom sonar maps. In an offhand manner my host showed me some sonar records in which large areas were devoid of any topographic relief detail, such as sand ripples. He said that these unusual areas were where the residue of an oil spill had settled to the ocean floor and acoustically masked the normal bottom reverberation. Subsequently I asked several users of high-resolution bottom-mapping sonar if they had made similar observations of oil-spill residues on the bottom sediment; no one knew about such observations.

My interest in the subject was rekindled by a recent *Science* article about the *Amoco Cadiz* oil spill of March 1978 off the coast of Brittany (Grundlach et al., 1983). The article discusses the mixture of oil residue with the sediments but makes no mention of the use of side-scan sonar to detect, measure, and track the patches of bottom-resting oil.

In November 1983 I paid another visit to the French navy office and asked if they had published any of the oil-spill data that they had collected. They advised me that they had not issued any reports on the subject and had no plans to do so, but that I was free to write about their work. Evidently they observed the patches for a year or more, tracked the movements, the eventual breakup of the patches, and the gradual reduction of patch thickness. They have a considerable body of data.

The sonar used by the French navy for their bottom surveys is the DUBM-41B, developed by Thomson-CSF, Brest, for the navy. This instrument is probably the best of the modern side-scan sonars in terms of resolution and signal processing. It has a range resolution of 8.0 cm, a cross-range resolution of 12.0 cm, and a range of 50 m. The transducers are mounted in a body which normally is towed 6.5 m above the bottom at a speed of 4 kn. The towing ship is an ex-US Navy minesweeper. A complete system consists of two towed bodies, a magnetic tape recorder, and a precise radio navigation system. Bottom sonar surveys are normally made in water depths of 100 m or less.

The sonar records show a lack of bottom backscattering. This feature probably means that the high-frequency sound is largely absorbed, but it also could, at least in part, be due to the oil residue forming a plane surface over the normal sand ripple relief, resulting in strong specular reflection. Most of the cargo of the *Amoco Cadiz* was light Arabian oil, but some bunker fuel C was spilled as well. In March 1980 the tanker *Tanio* spilled some 7000 tons of oil in the same general area. The sonar maps I saw could have been from either of the two spills, or they might have been of the heavy crude only.

The oil patches were observed for a year during routine surveys. The patches drifted some and eventually began to break up into smaller patches. At the same time the sonar operators began to observe faint traces of sand ripples showing through the oil, indicating a slow dissipation of the oil. The oil patches presented an unexpected operational problem. The towed body has a built-in, high-frequency depth sounder, the output signal being used to automatically control the body to operate at a constant height above the bottom. When the body was towed over the oil patches, the bottom echo was reduced to such a low level that automatic height control was not possible. This result seems to provide strong evidence that the sound was being absorbed rather than specularly reflected by the oil layer. I believe that French navy divers obtained samples of the oil patches, but I was not able to obtain any details.

The purpose of this article is to suggest that some of the modern (and readily available) high-resolution, side-scan, bottom-mapping sonars may be useful tools for investigating oil spills and other forms of pollution materials for which at least some component settles to the ocean floor. Perhaps (unknown to me) these sonars are already being used for this purpose.

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*12/13/83*

## THE MARGINAL ICE ZONE EXPERIMENT

*by Robert Dolan and Robert Booker. LCDR Booker is the Naval Applications Officer for Environmental Systems and Military Oceanography at the Office of Naval Research's London Branch Office.*

The marginal ice zones (MIZs) of the Arctic and Antarctic vary seasonally over an area of about 25 million km², or 7 percent of the world's ocean areas. The processes that control the location and behavior of the MIZ are of fundamental importance to meteorologists and oceanographers. In addition, understanding the processes that determine the MIZ is important in ocean transport, naval operations, and the development of fisheries. Sea-ice movement is also a major factor in almost all aspects of Arctic offshore oil field development. The dynamic nature of pack-ice must be designed into the location of exploration rigs and production platforms, logistics, and transportation and construction methods.

Consequently, a large-scale field investigation, known as MIZEX (Marginal Ice Zone Experiment), was initiated last summer, with a second phase scheduled for the summer of 1984 (MIZEX 84). The MIZEX program--which is primarily sponsored by Norway, the Federal Republic of Germany (FRG, or West Germany), France, Denmark, and the US--involves more than 300 scientists and staff. The scientific teams are divided into seven subgroups: remote sensing, meteorology, biology, ice dynamics, acoustics, oceanography, and modeling.

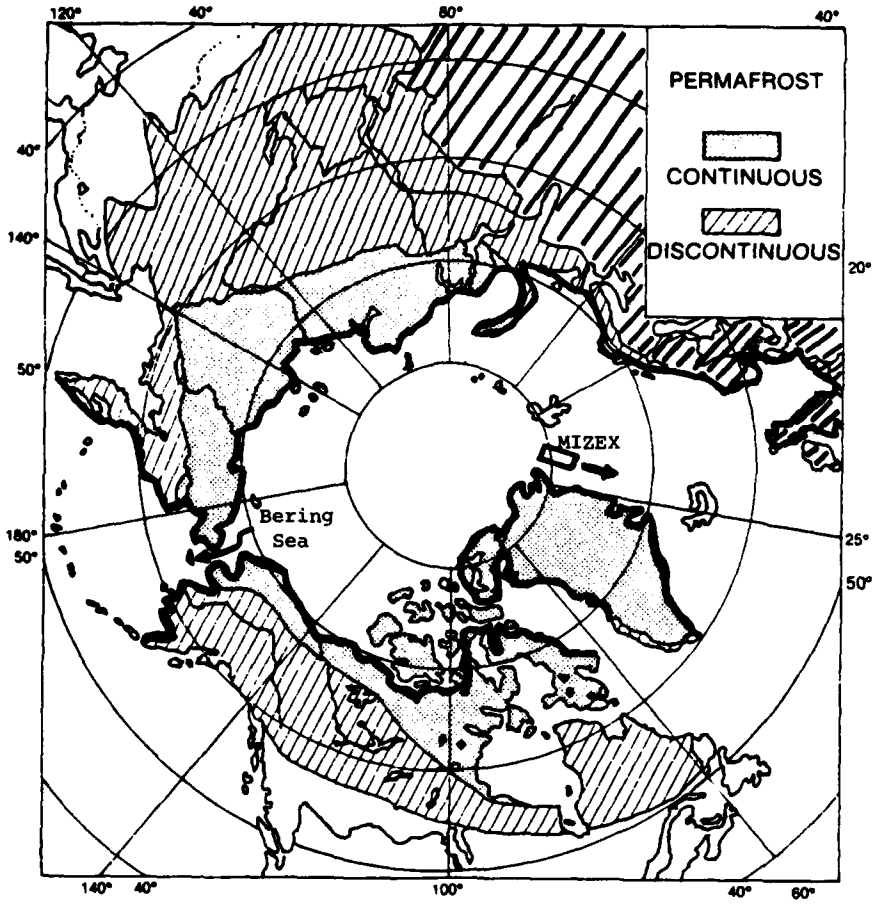


Figure 1. Site of MIZEX.

MIZEX is being carried out in Fram Strait, between Greenland and Spitsbergen (Figure 1). This area was selected because the Fram Strait is the primary opening between the Arctic Ocean and the Atlantic. Most of the heat and water exchange between the Arctic Ocean and areas to the south occurs through this reach. The Bering Sea, which is also a MIZ, is responsible for only a small percentage of the Arctic Ocean's heat and water exchange.

MIZEX 84 is a "drifting" experiment, covering an area of about 200 km². During the experiments, one of the five oceanographic ships involved will be moored to the ice in the middle of the area, 30 to 50 km inside the ice edge. This ship will serve as the base station. Another ship will penetrate further into the ice pack, while one ship will be stationed at the actual edge of the ice, and two ships will operate in the open water outside the ice edge. In addition, almost daily remote-sensing overflights will map the drifting experimental site with a full range of instruments, including synthetic aperture radar (SAR), microwave sensors, and photography. Some of these data will be made available on virtually a real-time basis to the field investigators.

From 14 through 22 November 1983 the Alfred-Wegener Institute for Polar Research (Bremerhaven, FRG) hosted a meeting to review the preliminary results of MIZEX 83 and to finalize the design of MIZEX 84. The presentations, programmed according to the seven subgroups, were generally excellent. On the whole, the investigators are young, dedicated, and enthusiastic about their work. We are particularly impressed with their cooperative attitude, and we believe the program will become even more "interdisciplinary" after MIZEX 84 has been carried out and the research teams have had an opportunity to analyze their data and exchange results.

Ice Dynamics

The MIZEX ice studies are divided into those concerned with the growth, decay, and internal properties of the ice and those concerned with the

dynamics of the ice in response to atmospheric and oceanographic processes. Several investigators at the Bremerhaven meeting reported on the characteristics of the MIZ from the edge through the transition zone to the interior pack, some 50 km from the edge. Ocean waves are an important contributor to the fracturing processes and the maintenance of the broken pack-ice form. Evidence of gravity waves, although greatly attenuated, can be detected up to 30 km into the pack ice. The ice in the MIZ is significantly different from that of the interior pack. In the MIZ the ice is subject to higher energy wave action (large waves), which can cause it to break up into smaller floes. The floes become larger and less mobile deeper into the pack.

Along the MIZ the greater number of floes produce air-ice and ice-water drag coefficients that are different from those of the ice found further in the interior. This in turn has significant bearing on floe dynamics. Floe movement, incidently, has been tracked for up to several kilometers per day. Measurements made during MIZEX 83 and planned for MIZEX 84 include changes in ice mass, floe concentrations, floe sizes, and the "energy budget" along the ice edge. In addition, a team is using cores and *in-situ* measurements to examine the properties of the ice itself. The overall kinematics of the ice drift will be monitored by radar positioning and satellite navigation. The ice-dynamics team will also measure wave and collision processes, ablation, and ocean currents at the ice edge.

Oceanography

Oceanographic conditions along and across the MIZ are as complex as those in any zone of comparable size. Last summer the oceanographers found permanent and transient frontal systems, large and small eddies, and upwelling. These range in size from tens of meters to kilometers; and to complicate the picture, the MIZ corresponds with a permanent oceanic front, the East Greenland Polar Front, which separates the cold, low-salinity, southward-flowing East Greenland current from the more saline water of the Greenland Sea. In addition, the oceanographic team found large meanders along the ice edge, 20 to 40 km in wavelength.

SAR has shown evidence of eddies that are 50 km in diameter and larger along the ice front. These may have warm-water cores down to at least 600 m. Upwelling along the front is less common, but the 1983 field investigators found evidence of upwelling from a depth of 150 m to the surface along a 10-km zone of the ice front. This upwelling is believed to be caused by changes in the wind stress across the ice edge due to the variation of the air drag between open water, broken ice floes, and smoother ice, and to stability variations in the atmospheric/surface boundary layer.

Meteorology

The MIZEX meteorologists believe the most important processes along and across the MIZ are those that control the ice edge by exchanges between the atmosphere and the ocean or the ice. Wind stress at the surface contributes to ice drift, wave and current generation, and mixing. The magnitude and direction of the stress are a function mainly of the pressure gradients and the stratification and shear in the atmospheric surface layers and the planetary boundary layer. Wind stresses are also related to the changing surface roughness of both the ice and the ocean. The MIZEX 84 meteorologists are planning experiments to determine wind stress under several of these conditions.

Heat exchanges to and from the atmosphere strongly influence ice growth, the temperature of the ocean surface, and convection processes in the upper ocean. Determining the roles of these processes and atmospheric states is fundamental to understanding how the ice and underlying water respond to the wind.

The MIZEX 84 meteorologists will use a variety of instruments for surface layer studies from ships and ice floes--along with aircraft boundary-layer measurements, radiosonde launchings, acoustic sounders, closely spaced surface-pressure arrays, and buoy-mounted weather stations. They will have a modeling effort too.

Biology

The 15 MIZEX biologists will measure phytoplankton biomass, phytoplankton species, nutrients, zooplankton biomass and diversity, and a variety of chemical parameters. At the Bremerhaven meeting there was some question about the actual productivity within the MIZ of the Greenland Sea. Apparently, the high levels of primary productivity found in the Bering Sea are not present in the Greenland Sea. One of the biologists who participated in MIZEX 83 reported that few fish and birds and virtually no mammals were sighted during last summer's field experiments. A possible explanation is that the Greenland Sea and the Fram Strait are deep, with steep continental shelves--whereas the Bering Sea is shallow continental shelf. The shallow-water environment, along with

high levels of nutrients, contributes to high productivity in the Bering Sea MIZ. A mixed layer is stabilized by melt water from the ice pack, and high nutrient levels are associated with ice-edge upwelling. These conditions are not prevalent within the Greenland Sea.

Acoustics

There are few places in the ocean as "noisy" as the MIZ. To begin with, the ice itself is noisy, especially along the edge, where waves and currents move and fracture the ice floes. The sound-speed profile is also subject to significant variations due to the frontal and eddy structures. These variations degrade horizontal coherence of acoustical wave fronts, which can affect the efficiency of directional acoustic arrays.

Acoustical experiments to be carried out during MIZEX 84 include monitoring of fixed and drifting sonobuoys, measurements of ambient noise (including directional information), seismic reflection and refraction experiments, and possibly an investigation into the potential of acoustical tomography.

Remote Sensing

In MIZEX, remote sensing is used as a measurement technique not only for supporting the field investigations, but also for a separate series of experiments. It was stressed at the Bremerhaven meeting that it is inevitable that sooner or later the MIZ research community would become dependent on remote sensing, because of the limited time scales and heavy costs of large field experiments like MIZEX. Thus, it is essential for the remote sensing data and techniques to be integrated with all aspects of MIZEX. So far, this goal is not fully apparent in the program and elsewhere, but MIZEX 84 offers a superb opportunity.

The objective of the MIZEX remote sensing program is to provide the investigators with SAR, side-looking airborne radar, passive imagery, and aerial photography. The facilities being assembled will permit almost real-time data; the investigators will help with practical interpretation. In addition, the remote sensing data will be evaluated for future geophysical monitoring, including data from satellites, several aircraft, and devices placed on the ice packs. This evaluation will be carried out simultaneously with the main field experiments in order to maximize the potential of remote sensing via verification with ground-level measurements.

Modeling

Although the modeling team for MIZEX is a separate group, and it appears to be functioning somewhat independently of the other teams, the goal of MIZEX is to have geophysical models developed that will simulate or predict the processes along and across the MIZ. These models will be tested and calibrated with the data collected during MIZEX 83 and 84. The modeling effort includes: sea-ice radiation, thermodynamics, ridging, breaking, and rheology; atmospheric and oceanic boundary layers; eddy generation; frontogenesis and maintenance of fronts; quasisteady, mesoscale circulations in the atmosphere and ocean; fine structure and cross-frontal mixing; biological processes; internal waves; sound path and acoustic tomography; and many others.

In addition to being considered the main goal of MIZEX, modeling is being used before the 1984 experiment to optimize sampling strategies. However, there have been some heated discussions within the modeling team and between the team and the observationists. There are some distinct communication gaps in MIZEX, as one might expect within a project this complex; but the gaps do not appear to be insurmountable--the MIZEX teams do talk with each other. Klaus Hasselman (Max-Plank-Institute, Hamburg) expressed some concern about the discrepancy between the questions being considered in the modeling versus the dimensions of the field data. That is, the modelers may be attempting to model large-scale processes with small-scale data. We believe MIZEX 84 will help close the gaps--especially if the remote sensing is successful.

The Field Program for MIZEX 84

As mentioned earlier, the MIZEX program is a drift experiment with one ship moored within the moving ice-pack and the four other ships sampling other environments. In addition, the field work will be supported with five helicopters and several aircraft. The moored ship in the ice-pack is expected to drift about 10 km per day, or 400 to 500 km over the 6-week period.

Oceanographic, meteorological, and ice mapping will be carried out on fixed geographical grids. The region of intense mapping will cover about 100 to 200 km of the ice edge, starting 40 to 50 km outside the ice margin and extending 40 to 50 km into the pack. The drifting ship, the new German research icebreaker *Polarstern*, and the open-water ship with the ice-breaking capability will drift throughout the region and provide observations of ice drift

and oceanographic and meteorological processes. Other ice-strengthened and the open-water ships will follow parallel tracks. The grid lines will be directed perpendicular to the ice edge and spread 5 to 10 km apart, with stations spaced at 2- to 4-km intervals in order to measure the small eddies with a diameter of 10 to 15 km. The MIZEX 84 program calls for the remote sensing and meteorological aircraft to fly over the area at least every 1 to 2 days. An aircraft staging site at the Tromso Satellite Station in northern Norway will coordinate all aircraft flights and transmit information to the scientific teams on the ships.

Table 1 shows the ships and aircraft and their measurement responsibilities. The following is a listing of the major measuring systems that will be used in MIZEX 84:

1. Atmosphere: standard ship meteorological instruments. Eddy flux, profile and dissipation sensors, aerosol counters, radiometers, acoustic sounders, radiosondes, and pressure sensors on ships and buoys. Gust probes, dropsondes, scatterometers, and other remote sensors from aircraft.

2. Ocean: CTD, batfish, freefalling velocity probes, current profiling systems, Argos-tracked drifters and ODAR radar for surface current, and expendable probes for temperature and salinity profiles.

3. Ice: deformation array, floe collision sensors, directional wave buoys, upward-looking ice profilometer, sonic ablation detector, and parachute-dropped buoys tracked by Argos.

4. Remote sensing: X-, C-, L-band airborne SARs, Kaband imaging radars, multifrequency microwave radiometers and

Table 1

Measurement Responsibility

| *Platform* | *Helicopters* | *Work* | *Days* |
|---|---|---|---|
| Icebreaker | 2 | Synoptic CTD mapping in ice | 22 |
| | | Deploy and retrieve met-ocean array in ice | 5 |
| | | Deploy and retrieve four Cyclesondes | 3 |
| | | *Help* ice-stengthened ship in heavy ice conditions | 6 |
| | | Microwave properties of sea ice and CODAR | 6 |
| | | Meteorological observations, radiosondes, acoustic sounder | |
| | | Biological measurements | |
| Drifting ship in ice | 2 | Ice deformation and dynamics | |
| | | Ice structure studies | 42 |
| | | Ice thermodynamics | |
| | | Cyclesonde deployment and retrieval | |
| | | Microwave properties of sea ice | |
| | | Hourly meteorological observations, radiosondes | |
| | | Acoustic sounder, flux profilers | 4 |
| | | Atmospheric boundary layer studies | |
| | | Swallow float tracking | |
| Ice-strengthened ship | 1 | Synoptic CTD mapping | 5 |
| | | Eddy CTD mapping | 15-20 |
| | | Upwelling | 5 |
| | | Bands and streamers | 5 |
| | | Detailed examination of ice front | 5-10 |
| | | Deploy and retrieve directional wave buoy | 2 |
| | | Hourly meteorological observations, radiosondes | |
| | | Atmospheric flux profilers | 4 |
| | | CODAR, swallow float tracking | |
| Open-water ships | | Synoptic CTD mapping in open ocean | (each) 23 |
| | | Eddy CTD mapping-fronts and upwelling | 14 |
| | | Deploy and retrieve met-ocean arrays | 5 |
| | | Hourly meteorological observations | |
| | | Radiosondes, acoustic sounder | |
| | | Atmospheric boundary fluxes | |
| | | Aerosol size distribution | |
| Submarine (if available) | | Sonar profiling—20 transects with longitudinal ties | 10 |
| | | Sound velocity profiling across fronts | |
| | | XBTs, CTD profiling across fronts | |
| Aircraft | | SAR mapping—long-range aircraft | 20 flights |
| | | Correlative passive-active microwave data under different environmental conditions | 15 flights |
| | | Combined meteorological-remote sensing aircraft for wind stress | 20 flights |
| | | Boundary layer studies, surface temperature, albedo, roughness, ice distribution, photography. | 20 flights |
| | | Marine winds from scatterometer | 20 flights |
| | | AXBT flights | 10 flights |

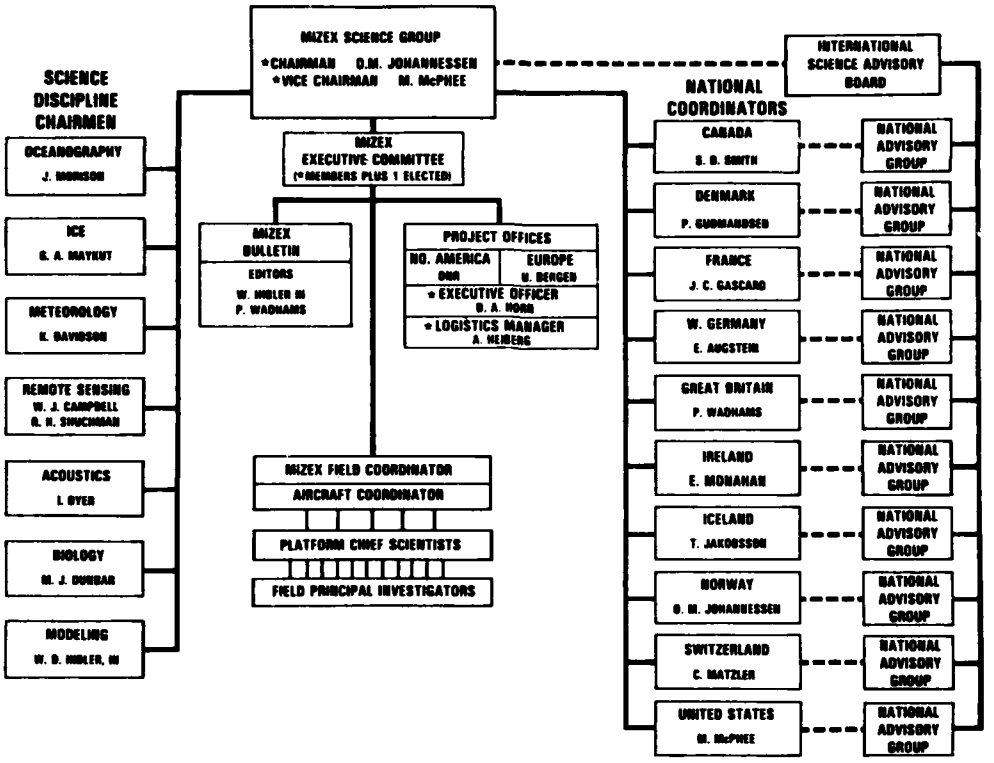


Figure 2. MIZEX organization.

scatterometers, portable *in-situ* ice dielectric system, *in-situ* multifrequency scatterometers and multifrequency passive microwave array, and raft-mounted Lunenberg target calibration lenses.

Coordination

Management of a complex research program such as MIZEX is a major responsibility, and competition for resources and ship space is keen. Therefore, an international MIZEX organization has been established to provide overall coordination and arbitration of conflicts (Figure 2).

The US Office of Naval Research (ONR) considers the MIZ to be a high priority area and has made a major investment in the MIZEX program. Many of the scientists and staff are supported directly or indirectly by ONR. The ONR branch office in London provides a direct liaison with the European participants and assistance to the MIZEX organization.

*12/12/83*

# PHYSICS

## A 50-PICOSECOND GATED X-RAY INTENSIFIER

*by David Mosher. Dr. Mosher is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until July 1984 from the Naval Research Laboratory, where he is Supervisory Research Physicist.*

Many aspects of plasma physics research require x-ray images which are highly resolved in both time and space. In inertial confinement fusion studies, x-rays emitted from laser or particle-beam heated surfaces provide information on the density, temperature, and dynamics of ablating plasmas. Similar x-ray sources are used to back-light spherical targets to study the quality of their implosion, and planar targets to study the growth of instabilities and inhomogeneities produced by nonuniform irradiation. Time-resolved x-ray imaging is also important to the study of intense

radiation sources produced by the electromagnetic implosion of annular z-pinch plasmas. These sources were developed within US Department of Defense programs for nuclear weapons vulnerability testing and are currently being applied to materials science, semiconductor-circuit lithography, and x-ray lasers. Good diagnosis of plasma conditions is especially important for x-ray laser research because precise density and temperature distributions are needed to achieve excitation of lasing states.

All of the above studies require x-ray source temporal resolution of at least 1 ns and spatial resolution of about 100 μm. The most severe resolution requirements arise in the study of laser-driven fusion targets, where 10 μm and 100 ps are useful. J.D. Kilkenny and coworkers at the Blackett Laboratory of Imperial College, London, have developed a gated x-ray intensifier which promises to meet these performance standards for experiments to be conducted at the UK's two major centers for laser-produced plasma research: the Rutherford Appleton Laboratory and the Atomic Weapons Research Establishment. The device tests the principle of fast gating an image tube photocathode to obtain time-resolved images. Initial measurements described below show that the gating time is about 50 ps and that contrast ratios of about 100 to 1 can be achieved for soft x-ray sources.

To achieve the high performance, a CsI photocathode is vacuum deposited onto an aluminum substrate that is the live conductor of a 50-ohm microstrip transmission line with a low-loss substrate. The ground electrode is a copper mesh that is 70 percent transparent to electrons emitted by the photocathode. Photoelectrons produced by pinhole imaging of the x-ray source onto the photocathode pass through the mesh to a Varian 8900Y microchannel plate (MCP). A DC voltage is applied to the MCP operating at a gain of about $2\times10^4$. The MCP output strikes an aluminized P11 phosphor layered onto a fiber-optic output window. The intensifier operates in the vacuum of the laser-target chamber, and the fiber-optic window transfers the image to a film disk outside the chamber.

Fast gating is achieved by propagating a short voltage pulse across the photocathode. The gate pulse is produced with a photo-conductive switch (Auston, 1975) using a chromium-doped GaAs element bonded conductively to the transmission line. The Auston switch produces a fast rising pulse but a slowly falling one. The fast fall required for crisp turn-off of the intensifier is produced by forming the transmission line loop shown in Figure 1. The positive and negative pulses from the switch propagate in opposite directions. The cable lengths are adjusted so that the negative pulse arrives at the photocathode about 100 ps before the positive one. A DC bias of 100 V is applied to the photocathode to suppress electron transmission to the MCP when the 2-kV gate pulse is absent.

Several plasma x-ray sources were produced from one laser pulse to test the intensifier. A 5-J, 100-ps, 1.06-μm pulse was split with an angled reflection etalon to produce three focal spots on a copper target. The spots were separated by 400 μm in space and 200 ps in

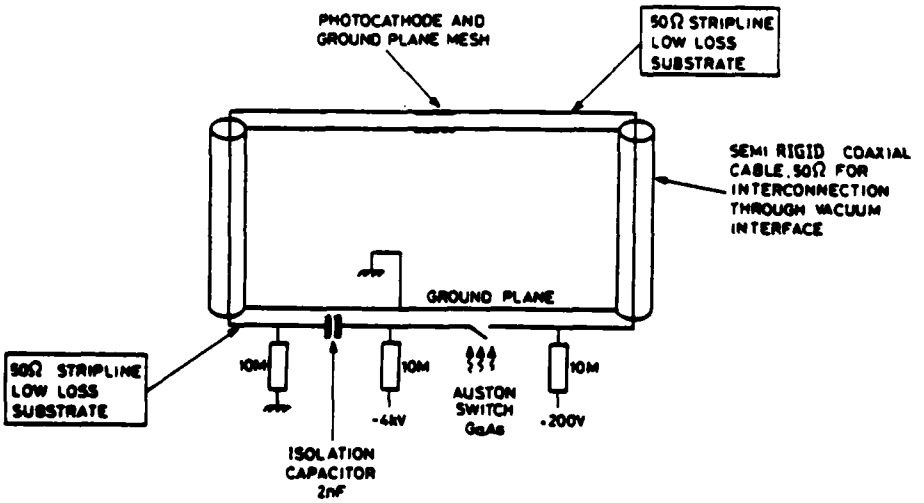


Figure 1. The gating circuit.

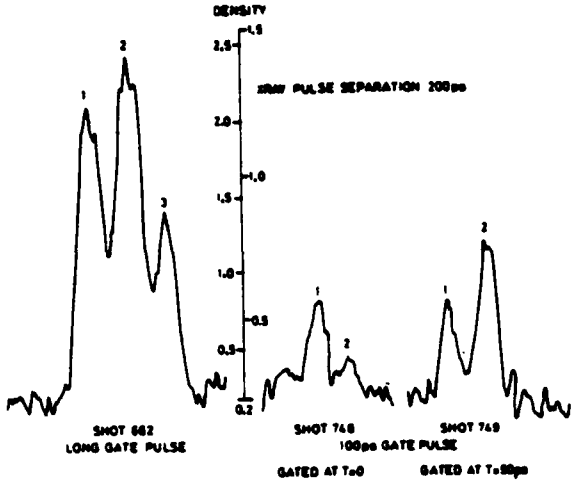


Figure 2. Microdensitometer traces across gated x-ray images.

time. Part of the same pulse was used to drive the Auston switch. The x-ray sources were imaged onto the photocathode with 1-to-1 magnification using a 50-μm-diameter pinhole.

The Cu x-ray spectrum consisted of a continuum with broad bands of L-shell line transitions. The intensifier could record images when gated off because the photocathode transmits a substantial fraction of the Cu spectrum to the MCP. Tests without gating gave a null signal corresponding to a contrast ratio of 100 to 1 with and without gate pulses.

Some results are shown in Figure 2 for three laser shots and different gating conditions. On shot 622, the gate pulse was made very long, and the intensifier imaged the three sources. Shots 748 and 749 had 100-ps gate pulses with 749 gated 50 ps later than 748. The intensity of source 2 has risen considerably with the 50-ps shift, demonstrating a discrimination time of about 50 ps for gate turn-off. Gate turn-on should be at least as good because the two legs of the strip line circuit are symmetric.

The major limitation of the present device is the contrast ratio between the gated and straight-through images. The problem gets worse as the x-ray spectrum hardens. A new tube has been built which promises to overcome the contrast problem. In the new device, the straight-through image is separated from the gated image by angling the tube axis with respect to incident x-rays. A 0.2-T magnetic field is imposed to bend photo-electrons around to the MCP without loss of resolution (Berg et al., 1966). The gating system will also be improved by going to a single-ended line configuration and using a commercially available triggered-pulse generator in place of the Auston switch. The new device is currently under testing at the Rutherford Appleton Laboratory, and 50-μm spatial resolution has been demonstrated.

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*12/14/83*

## MATERIAL-RESPONSE RESEARCH WITH HIGH-POWER GAS LASERS

*By David Mosher.*

The development of powerful, continuous wave (cw) gas lasers in the mid-1960s has led to industrial applications for a variety of material processes (*ESN* 36-11:303-308 [1982]). The heavy industrial processes--such as cutting, drilling, and welding of metals--require cw powers above 1 kW, focused power densities in the $10^7$ W/cm$^2$ regime, and can involve materials in all four states of matter: solid, liquid, vapor, and plasma. A thorough understanding of the laser-matter interaction is required to ensure the economical production of high-quality materials. Liquid flow and resolidification at weld or cut faces must be carefully controlled to obtain acceptable strength or uniformity. Ionized vapor clouds above cut and drill surfaces can absorb the incident laser power and prevent continuous processing of the underlying solid material. This material response problem is similar to that encountered in directed-energy research, where the laser must be focused on moving targets for sufficient time to penetrate metal superstructures.

The Physics Institute II at the University of Düsseldorf (Federal Republic of Germany) is engaged in a broad range of research and development activities in the laser-matter area. The program was described to me by Prof. J. Uhlenbusch, director of the 35-member institute. Work there is devoted to the refinement of high-power cw lasers for materials research and processing, the interaction of such lasers with matter, and the development of relevant diagnostic techniques. In this article, the $CO_2$ laser facility is described, results of weld and optical discharge experiments are presented, and measurements of

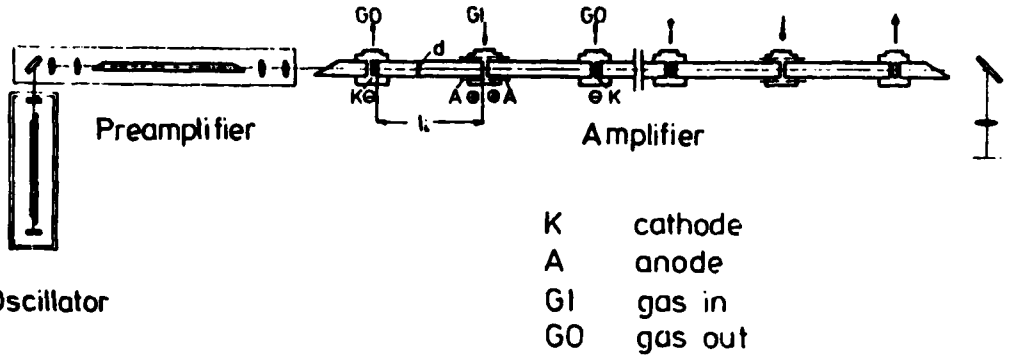


Figure 1. Oscillator-amplifier system schematic.

laser absorption in melting aluminum are discussed. Unexpected changes in the absorption at the melting point provide important data for assessment of $CO_2$ lasers in defense applications.

Laser Development and Materials Processing

The laser development program concentrates on optimization of a high-power, cw monomode, $CO_2$ laser. Such a laser is ideal for materials processing for a number of reasons. Continuous and high-power operation are required for high-speed processing of industrial materials. Fine cutting and welding operations at economical processing speeds require power densities in the $10^7$ to $10^8$ W/cm$^2$ regime. The tight focusing and stable operation required at these power densities are best achieved with the high beam quality of single-mode laser operation. Continuous laser operation also benefits basic research into the nature of the material response through the achievement of steady hydrodynamic flow and equilibrium states of matter that greatly simplifies both measurements and modeling.

A schematic view of the oscillator-amplifier laser system is shown in Figure 1. Although high-power $CO_2$ lasers frequently combine oscillator and amplifier functions in a single cavity, highly stable monomode operation is best achieved by separating the two elements. The oscillator is a diffusion-dominated $CO_2$ laser tunable to different wave lengths with passive and active cavity stabilization elements. The oscillator operates in the TEM 00 mode (the fundamental cavity mode with transverse electric and magnetic fields) and generates a beam of about 20 W. The main amplifier is a 10-m-long device consisting of 14 convectively cooled glass segments. A swirling gas flow is produced in these segments by a Roots pump, and the He-$N_2$-$CO_2$ mixture is excited by 22-keV, 150-mA electrical discharges.

During the past year, the output power of the system was increased from 3.5 to 7 kW by optimization experiments carried out on a separate two-segment test section. Gas pressure, composition, mass rate, inlet geometry, and discharge current were varied to optimize output. The main diagnostic technique used to probe the discharge was resonance scattering of a cw dye laser. Local Doppler shift and broadening measurements on He line profiles provided the radial gas temperature and velocity profile (Odenthal and Uhlenbusch, 1980). The best operation, and a gain maximum of 1.2 percent per centimeter were achieved with homogeneous temperature and velocity distributions in the discharge.

Researchers at the Institute have demonstrated the applicability of the monomode laser to an industrial process by performing high-quality weld experiments on 0.2-mm-thick tinplate. Two sheets of tin were aligned on a drum which rotated under the laser focus. With an optimized laser-spot diameter, a welding speed of 50 cm/s was reached at about 3-kW output power. The theoretically predicted linear relation between processing speed and laser power was demonstrated at lower power. A polished section of the weld is shown in the photomicrograph of Figure 2. Uhlenbush stated that the high quality of the weld could be attributed to the good mode quality of the laser beam.

Optical Discharge Experiments

The most violent and complex response of materials to intense laser irradiation is encountered in cutting and drilling operations. In these cases, the laser intensity is sufficient to

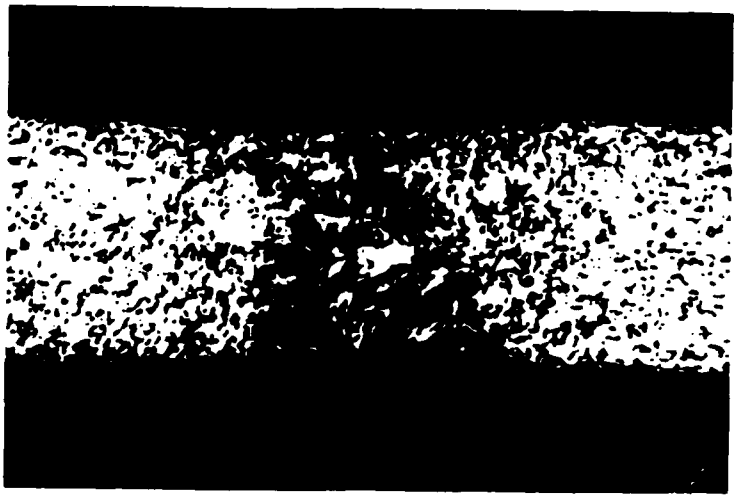

Figure 2. Cross section of tinplate weld.

vaporize and ionize the material, producing a plasma cloud which can block penetration of incident radiation to the underlying solid material. This blockage produces irregular surfaces in processed materials and is responsible for reduced lethality of laser beams in defense applications. Because of complexities associated with asymmetric geometries, time-dependent effects, complex flow patterns of the liquid and vapor phases, and ionization phenomena in the vapor, the laser-matter interaction is difficult to analyze. Uhlenbusch and coworkers have performed continuous optical discharge (COD) experiments which allow one to separate out the gas and plasma phase phenomena and study them in a sym- metric geometry under steady-state conditions.

Figure 3 shows the optical discharge experiment. The $CO_2$ laser beam enters a high-pressure discharge chamber thrcugh cone-shaped windows composed of ZnSe or KCl and is focused by a gold-coated Be-Cu mirror to an intensity of $10^7$ to $10^8$ W/cm$^2$ at a point a few centimeters above the mirror. For reported experiments, H, He, and Ar gases at pressures up to 200 bar filled the vessel. A thin tungsten wire used to start the discharge is removed after ignition.

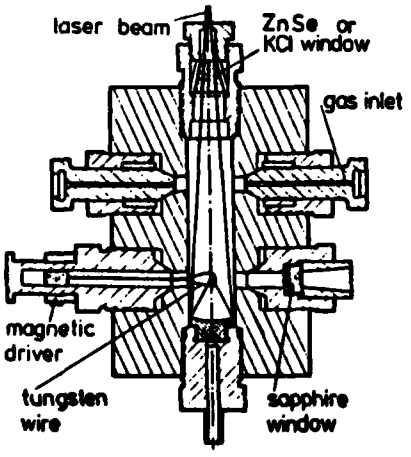


Figure 3. Optical discharge experiment.

Once the discharge is initiated, sufficient electron density is available to absorb laser power by the mechanism of inverse bremsstrahlung (the reverse of the process responsible for continuum radiation). A continuous discharge can be established at the focus if laser heating is sufficient to compensate for energy loss and recombination due to thermal conduction, convection, and radiation processes. Stable operation (i.e., a symmetric and time-independent density and temperature distribution) is only achieved about 20 minutes after ignition. This is the time required to remove metal impurities from the gas and for the chamber walls to reach a uniform temperature. It is crucial for stable operation that the laser beam and discharge vessel axes of symmetry be coincident so that a symmetric free-convection flow field can be established in the gas surrounding the COD.

The plasmas produced by this technique have a number of interesting properties. Stationary plasmas of $10^{17}$ to $10^{18}$ cm$^{-3}$ density and 1- to 2-eV temperature are produced within a radius of a few millimeters. The COD is therefore in local thermodynamic equilibrium so that modeling of atomic physics processes and analyses of spectroscopic

measurements are particularly simple. Convective flow velocities are in the centimeters-per-second regime in the cold outer region, and the motion has a pattern similar to that surrounding a candle flame. In fact, the simple geometry and single-constituent gas lead to simple convective flows which are interesting to study in their own right.

Several diagnostic techniques are used to probe the plasma and surrounding gas. Continuum radiation measurements enable plasma temperature and density to be calculated with the aid of the Saha equation. These are confirmed by Stark-broadened line intensity and line profile measurements. Visible light interferometry determines the density and temperature fields in the region surrounding the COD, and laser-Doppler anemometry provides the flow field.

One of the major results of these investigations is determination of the minimum laser power that can sustain the discharge. This information is important if laser-blocking CODs are to be avoided in applications. The minimum intensity has been determined as a function of gas pressure, and the data were compared with an ionization model which balanced inverse bremsstrahlung against electron diffusion, radiative recombination, and three-body recombination. The impressive agreement shown in Figure 4 demonstrates the detailed understanding of phenomena which is possible with a COD. A second result demonstrated the importance of the convective flow field to the energy budget of the COD. A simple hydrodynamic model employing a gaussian-shaped laser beam and radial and axial conduction and convection reasonably described the local temperature distribution and overall COD parameters (Uhlenbusch, 1983). These results provide confidence that simple models can be applied with some success to a subset of the complex phenomena associated with laser-matter interactions encountered in industry and defense.

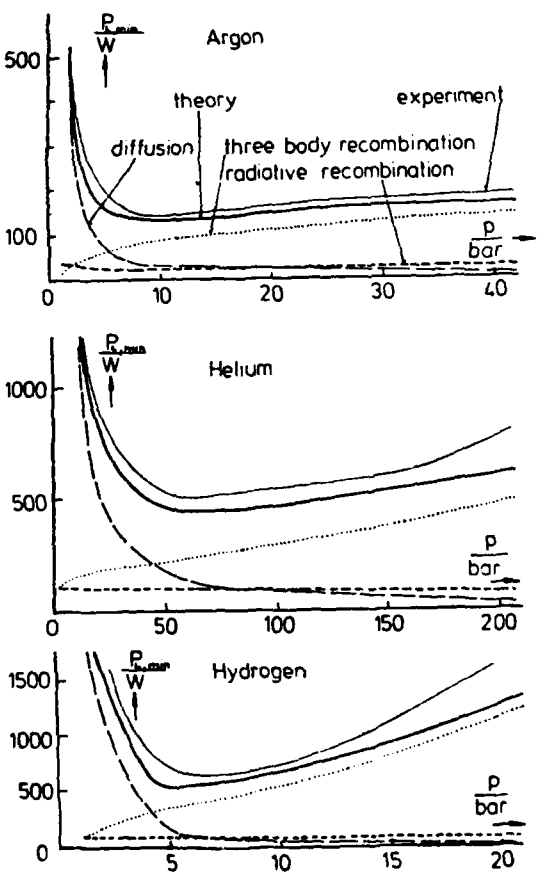


**Figure 4. Minimum laser power versus gas pressure.**

## Optical Constants of Melting Aluminum

For a detailed description of the interaction of laser beams with metal surfaces, a thorough knowledge of the absorption coefficient is necessary. For welding, cutting, drilling, and hardening operations involving $CO_2$ lasers, the temperature behavior of absorption at $\lambda = 10.6$ μm must be known in the regime where phase changes occur. A few workers have reported on the subject, but absorption data have been reported only up to a few degrees below the melting point (Sekhan and Mehrabian, 1981). Uhlenbush and coworkers extended absorption data above the melting point of aluminum in order to understand an irregular behavior due to melting in processed aluminum.

A schematic of the experiment is shown in Figure 5. Absorption of linearly polarized $CO_2$-laser light was determined by ellipsometry as an aluminum target was heated in vacuum by an electric oven. The elliptical polarization of the reflected beam is analyzed by a power meter (PM) following reflection from a Brewster window (W2). PM

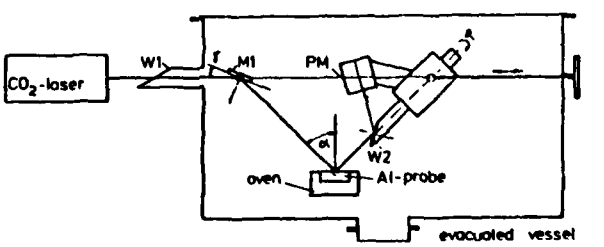


**Figure 5. Absorption experiment schematic.**

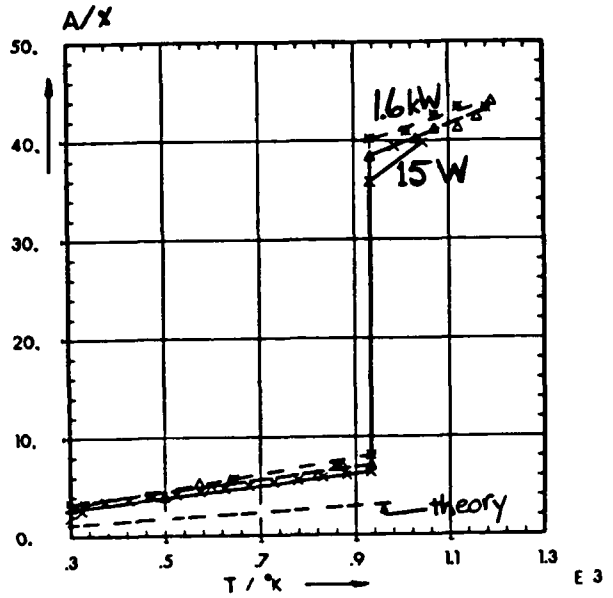


Figure 6. Absorptance versus temperature.

and W2 were rotated about the axis of the reflected beam to cover the complete ellipse. The angle of incidence $\alpha$ was varied from 30 degrees to 80 degrees, and the electric vector of the linearly polarized beam was oriented at 45 degrees to the plane of incidence. This orientation leads to a particularly straightforward determination of the complex index of refraction from the polarization of the reflected beam (Dreehsen et al.).

Measurements were performed for $CO_2$-laser powers of 15 W, 100 W, and 1.6 kW while the surface temperature of the aluminum target was continuously varied from room temperature to 1100°K. Figure 6 summarizes results as the temperature variation of percent absorptance. The small variations associated with the different laser powers are attributed to additional heating by the laser.

The most important feature of the results is a discontinuous jump at the melting point (933°K). The index of refraction decreases smoothly as a function of temperature and shows no such discontinuity. For completeness, the experiment is compared to the Drude theory for solid bodies, which is valid for 100-percent pure aluminum without surface oxidation. Since the experimental samples had both bulk impurities and surface oxidation, the poor agreement is considered tolerable. Although the electrical conductivity also experiences a jump at the melting point, incorporation into Drude's model cannot explain the change in absorptance.

The observed enhancement in absorptance by a factor of seven at the melting point is crucial for control of materials processed by lasers when the liquid phase is present. Uhlenbusch indicated that the behavior at melting is a new and unexpected result. If that is so, the observed discontinuity will be important to evaluations of laser lethality in defense applications.

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*12/13/83*

## SCIENCE POLICY

### EUROPEAN COMMUNITY STIMULATES RESEARCH

*by James W. Daniel, Scientific Director for Europe and the Middle East for the Office of Naval Research's London Branch Office. Dr. Daniel is on leave until September 1985 from the University of Texas, where he is Professor of Mathematics, of Computer Sciences, and of Education.*

The European Economic Community (EEC) has completed the first phase of its 2-year experimental program to make European R&D more effective by stimulating multinational research efforts. The EEC's Directorate-General XII for Science, Research, and Development has announced 34 research awards involving 88 institutions and some $3,800,000 (about 4,500,000 European Currency Units; 1 ECU in November 1983 was worth approximately $0.85). Among the awards is a $1,700,000 project on optical bistability that has an optical computer as its goal.

Background

The EEC's so-called "stimulation activity" was announced only in July

1983; it is a key part of the new European research and science strategy proposed for coordinating the EEC's entire research effort (see *ESN* 37-12: 455-456 [1983]). I recently spoke with Charles White, head of the stimulation program, about its goals and procedures.

According to White and to the formal announcement of the stimulation activity, the community believes its R&D efforts are as good as anyone's; they are not, however, being effectively translated into economically competitive advantages for the member states. Many difficulties appear to contribute to this inefficiency, and the formal announcement highlighted three:

"• The wastage of energy and resources arising from the fragmentation. . . in European research . . . .
• The increasingly damaging and irrelevant compartmentalization of activities, disciplines, and sectors in the European R&D system . . . .
• The difficulty of organizing resources quickly enough to develop promising new ideas or results."

The stimulation activity was created as an experimental approach to these difficulties.

## The Stimulation-Activity Experiment

On 1 July 1983 the EEC announced that it would spend almost $6,000,000 on its 2-year experiment--about $300,000 on administration and about $2,850,000 per year on research activities. If the experiment proves successful, the hope is to increase the annual outlay in stimulation activities to nearly $45,000,000 by 1987. In the experimental phase, support was made available to four types of activities:

• Research grants to facilitate mobility among researchers by funding: (1) travel and subsistence to transfer a researcher to work in a laboratory in another member state, and (2) salary and research for someone to join a research team for a limited period.

• Twinning contracts to facilitate cooperative multinational research by funding: (1) meetings among the researchers, (2) joint experiments, (3) exchanges of results, and (4) acquisitions of human and material resources.

• Subsidies to encourage information exchange by funding: (1) interdisciplinary European meetings; (2) specialized meetings involving basic researchers, applied researchers, engineers, and industrialists; (3) short-term exchanges of researchers; and (4) research designed to analyze and disseminate information on the strengths, weaknesses, and needs of European R&D.

• Operation contracts to link existing multinational teams in a major effort toward a scientific or technical breakthrough with a potentially important impact on EEC needs or problems.

Researchers in all member states were invited to submit proposals for any of the above activities and in any scientific field. In evaluating the proposals, however, preference would be given to those in seven fields chosen for special emphasis: (1) applications to pharmacobiology of new results in cellular and molecular biology, (2) transitory phenomena in climatology, (3) behavior of materials as they approach ignition under combustion conditions, (4) applications of mathematics to optics problems involving lasers and bistability, (5) applications of surface chemistry and surface physics to intersurface exchange, (6) applications of photometry and photoacoustics to the nondestructive analysis of materials, and (7) applications of solid state physics to structure phenomena and fabrication processes for composite materials.

## Proposals and Procedures

The call for proposals produced 1500 inquiries, of which 275 were soon submitted formally; of these, 258 met the requirements of the program and were thus eligible to compete for funding. The largest numbers of eligible proposals were from the UK and Italy, each with around a quarter of the total; next came France with about 20 percent, Belgium with about 15 percent, and The Netherlands with about 10 percent (note that very few were from Germany). The success of the plan in encouraging cooperative research is indicated by the fact that the 217 projects involved 514 different laboratories--95 in France, 82 in the UK, 64 in Belgium, and 61 in Germany, to name just the largest.

The proposals were evaluated by the EEC's Committee on European Development of Science and Technology (CODEST), which comprises one to four representatives of each member state. The individuals on CODEST are chosen by the Directorate-General XII, not by the member states themselves. The members are an impressive lot; Nobel laureate I. Prigogine is a Belgian representative, for example. The primary selection criteria for those proposals meeting the purposes of the program were scientific quality and value to the EEC; CODEST

also favored supporting young investigators in order to provide for the future.

The Results

Funds were awarded to 34 projects involving 88 laboratories. Twenty-eight of the projects are twinning contracts, with only three research grants and two subsidies. As planned, only one large operations contract was awarded, namely for research on optical bistability and its role in an optical computer; and in the second year of the stimulation-activity experiment, only proposals for twinning contracts, research grants, and subsidies will be eligible.

The largest share of the funds (about 26 percent) will go to proposals from the UK; France is close behind with about 21 percent. Italy garnered around 13 percent, as did Germany; without its funds in the large operations contract, however, Germany's share would be only 3 percent. Next comes Belgium with 12 percent; no others exceeded 10 percent.

Because of the selection procedure, the list should contain important research projects by many of the EEC's best younger individuals and groups. The EEC is confident that its stimulation experiment will produce high quality research, hopeful that it will help eliminate the perceived barriers to translating R&D into competitive advantages. It will be easier to judge the former's success than the latter's.

*12/1/83*

## BELGIAN R&D

*by James W. Daniel.*

Scientific and technological developments in Belgium reflect the same polarity found throughout that small nation: tension between Dutch-speaking and French-speaking populations versus the unifying forces of a popular monarchy and central government. The forces of fusion appear to be winning over those of fission, with the result that Belgian R&D is having increasing national impact with world-class status in several areas, such as molecular biology and thermodynamics.

Tensions between Belgium's two cultural groups affect the advance of R&D in a variety of ways. For example, a decade ago the French-speaking universities generally had few industrial ties, while the Dutch-speaking generally had many; political pressures from the French-speaking population brought about a successful effort to stimulate industrial cooperation in its universities. Both groups of universities presently have such productive ties, and the government pursues a now even-handed policy to stimulate still more; in many funding programs, industry-university interaction is a high-priority criterion for support.

As another example, consider Belgium's nearly 25-year-old effort to coordinate R&D policy nationally. Part of this effort seeks to coordinate the funding of research by the various governmental ministries; each of five--Economic Affairs, the Prime Ministry, Education, Public and Family Health, and Agriculture--contributes at least $40,000,000 annually to support R&D. Yet, historically, Belgian governments are usually coalitions of various parties; the chairmen of the advisory National Council for Science Policy and of the Ministerial Committee for Science Policy usually find it difficult to obtain agreement on R&D recommendations in the face of the typical serious political divergence.

These somewhat divisive forces, however, appear at most to slow Belgian technological progress rather than to stop it. The full range of R&D--basic research, applied research, development, and production--is supported and stimulated through both independent private sources and centrally controlled government sources. In a recent round of European Economic Community (EEC) research awards given on the basis of research excellence, Belgium received about 12 percent of the funding (see preceding article). For comparison, Belgium is generally considered to account for only about 6 percent of EEC resources. Thus it appears that Belgian R&D is successful. Let's examine where R&D policy comes from, what it is, and how it manifests itself financially.

Policy Formation

"Policy" of course evolves both somewhat randomly--through the individual actions of research groups in business and industry--as well as determinately, through government action. In Belgium, about 60 percent of R&D is funded by industry; this figure is more like 50 percent in most industrial nations. (Note: the government's view is that public support needs to increase in order to achieve balance and to lift total R&D support to the typical 2 percent of the gross national product for most industrial nations.) This funding is quite narrowly concentrated: of the about $800,000,000 industry spends annually on R&D, 25 percent is spent by

just four companies, 50 percent by 20, and 75 percent by 70; the remaining 25 percent is spent by the other 800 or so companies engaged in some sort of R&D. Viewed differently, 33 percent is spent in the chemical and pharmaceutical industries, 13 percent in electronics, and 11 percent in metals, with the remainder scattered widely. In this industrial sector, R&D policy of course is driven primarily by market forces and the existing industrial structure of the nation. Yet the government--with some success, as you'll see below--seeks to influence industrial R&D through various stimulation programs. Where are these government policies created?

Decisions on science policy are made by the Ministerial Committee for Science Policy (CMPS), chaired by the Prime Minister and including Ministers with responsibilities in science and education. Senior officials from those ministries form the Inter-ministerial Commission for Science Policy (CIPS), which implements CMPS decisions affecting two or more ministries. The CIPS is chaired by the Secretary General of the Science Policy Programming Services (SPPS), part of the Prime Minister's service staff. And it is this SPPS that provides the permanent professional ingredient for the government's science policy; it has responsibilities such as:

- Budget analysis and annual preparation of the science budget
- Planning measures to stimulate industrial research
- Planning measures to stimulate university research
- Analysis every 2 years of Belgium's scientific potential
- Operation of the "national programs" described later
- Administration of space research
- Formulation of policy on Belgian participation in cooperative science ventures with other nations.

Formal advice from outside the government comes from the National Council for Science Policy, composed of representatives from science, education, business, and industry; its present president, Prof. R. van Geen of the University of Brussels, is the first academic to head this influential advisory body. Through these various bodies is government policy on R&D formulated and implemented. What is the result?

## Government Science Policy

The formal aims of the Belgian science policy are to:

- Ensure that appropriate resources are available for scientific education, research, and development
- Coordinate resource use so as to eliminate duplication of effort
- Channel research efforts along lines consonant with community needs
- Provide scientific and industrial users of R&D with ready access to knowledge
- Stimulate exploitation of R&D for the economic and social benefit of society.

The present orientation of that policy is perhaps most clearly expressed in a February 1983 document from the SPPS, emphasizing "the inter-relationship between the expansion of higher education, the promotion of research, the development of the national technological potential and economic and social objectives and, therefore, the need to translate . . . action . . . into policy terms, so that science can be placed at the service of the nation's aims . . . ." Thus overall policy involves supporting basic research while increasingly seeking to stimulate and emphasize industrial applications of such research.

Basic research is supported primarily by the universities, which are in turn funded by the government; of this research support, some 26 percent is in physics and chemistry, 23 percent in medicine and pharmacy, 21 percent in biology and agriculture, 13 percent in social sciences, 10 percent in engineering, and 7 percent elsewhere. Additional government funds for basic research are distributed by various foundations: the National Fund for Scientific Research (FNRS), the Fund for Basic Collective Research (FRFC), the Fund for Scientific Medical Research (FRSM), and the Interuniversity Institute for Nuclear Sciences (IISN). Some basic research is also supported at various public institutions, such as the Botanical Gardens, the Royal Observatory, and the Service for Hydrological Studies. A special fund of roughly $10,000,000 per year is used for so-called "concerted research projects," generally 6-year plans to develop world-class centers of excellence in important fields at universities; there are now about 30 centers on such diverse topics as dissipative structures, molecular and cellular biology, microelectronics, new metal-based or polymer-based materials, surface science, integrated optics, and oceanography.

Belgium has developed several programs to stimulate industrial participation in and application of research. The Ministries for Economic Affairs and for Agriculture fund the Institute for the Promotion of Scientific Research in

Industry and Agriculture (IRSIA); collective research programs in industry and agriculture can receive 50 percent funding from IRSIA. The "national programs" run by SPPS devote roughly $20,000,000 annually to support research programs that are in specifically identified areas, involve both university and industry, and are planned to lead to the actual manufacture of a product by the end of the support period. The first such national program produced a numerical model of the North Sea that is widely used by industrial and governmental groups. Later national programs led to commercial products such as photovoltaic cells and wood gasifiers. The present national programs are in energy (especially solar, synthetic, and biomass); information technology (especially optical fibers, office automation, and microelectronics); aerospace and associated technologies (especially materials, electronics, and the Airbus program); and the life sciences (especially biotechnology and collections of strains). In general these national programs have been very successful in promoting university-industry interaction from fundamental research through manufacture.

Finances

Figures from the SPPS for 1983 show that government expenditures on research, development, *and education* totaled roughly $1,051,000,000, with sources distributed about as follows:

| | |
|---|---|
| National Education | $622,000,000 |
| Culture | $ 8,000,000 |
| Defense | $ 13,000,000 |
| Economic Affairs | $176,000,000 |
| Agriculture | $ 44,000,000 |
| Public Works | $ 4,000,000 |
| Prime Minister | $ 81,000,000 |
| Public & Family Health | $ 55,000,000 |
| Foreign Relations | $ 46,000,000 |
| Other | $ 2,000,000 |

The SPPS grouped the expenditures under six headings representing the use of the funds: $508,000,000 for the operation of universities; $54,000,000 for the specific support of university research; $205,000,000 for the support of research in agriculture and industry; $107,000,000 for research in public institutions other than in agriculture or industry; $75,000,000 for support of international organizations; and $102,000,000 for miscellaneous transfers to universities for such things as teaching hospitals.

Those funds specifically identified by the SPPS as supporting basic research were spent as follows:

| | |
|---|---|
| By universities | $122,000,000 |
| By the FNRS | $ 17,000,000 |
| By the FRSM | $ 12,000,000 |
| By the IISN | $ 13,000,000 |
| By the FRFC | $ 12,000,000 |
| In "concerted research projects" | $ 10,000,000 |
| For Belgium's support of CERN | $ 15,000,000 |

for a total of about $201,000,000. Those funds identified as for applied research were spent as follows:

| | |
|---|---|
| By the ministries | $62,000,000 |
| By government labs | $89,000,000 |
| By IRSIA | $92,000,000 |
| By "national programs" | $17,000,000 |
| By international programs | $48,000,000 |

for a total of about $308,000,000. The basic and applied research funds together total about $509,000,000 from the government, compared with the $800,000,000 typically invested by industry in R&D.

*12/2/83*

## GERMAN RESEARCH FOUNDATION: FUNDING PATTERNS

*by James W. Daniel.*

The Deutsche Forschungsgemeinschaft (DFG) is the primary organization in the Federal Republic of Germany (FRG, or West Germany) for the external funding of research in universities. It is similar to the combination of the US National Science Foundation, National Institutes of Health, National Endowment for the Humanities, and like agencies all rolled into one. The level and distribution of its monies among various programs thus reflect and influence the direction of West German research. This article examines recent and planned trends in DFG funding.

Background

The DFG is a not-for-profit private organization; approximately 53 percent of its overall funding comes from the FRG federal government, and 47 percent from the governments of the individual states in the FRG. A small amount of additional funds is raised privately. Its programs do not support institutes, but rather are intended for individuals or small groups. Its policies are determined by a complex system involving

a DFG general assembly, executive board, senate, board of trustees, grants committee, review committees, and so on; this pluralistic structure provides for decentralized decision-making, with much influence in the hands of research experts. Research projects are supported in a wide range of areas, including the natural sciences, the humanities, the arts, medicine, and engineering,

## Support Programs

The DFG manages several forms of research support; the most interesting from the perspective of US science are the so-called "Normal Procedure and Research Groups," "Priority Programs," "Special Collaborative Programs," "Heisenberg Program," and "Central Research Facilities."

Normal Procedure and Research Groups. Approximately 45 percent of the DFG's funds are spent each year in this program; it aims to support unsolicited research by an individual or group of at most six. Funds are provided to support staff, equipment, travel, publication, postdoctoral fellowships, and sabbaticals. Research workers--not institutions--are awarded the grants; any researcher, regardless of his or her employment situation, may apply. The table below shows the numbers of grant applications and the percentage funded in recent years:

| | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|
| Number of applications | 5419 | 6261 | 5941 | 6090 |
| Percent funded | 67.6 | 62.1 | 60.8 | 57.7 |

The DFG leadership is concerned about this steady drop in the percent funded and hopes to reverse the trend in the next few years.

Priority Programs. The DFG Senate occasionally identifies specific subject areas in which it wishes to stimulate research; applications are then solicited from selected individuals for 5-year research projects. The first such program was created in 1952; in recent years there have been about 100 Priority Programs operating at any time, consuming roughly 14 percent of the DFG's budget. Approximately 40 new Programs are presently planned for 1984-86, including areas such as parasitology; plasma diagnostics; the material, structure, and dynamics of the continental crust; nonlinear phenomena in the atmosphere; energy- and material-transport in phase transitions; and microcrystalline materials.

Special Collaborative Programs. This approach is used to fund centers of excellence in universities for 12- to 15-year periods; the host universities commit themselves to providing a sufficient base of staff and equipment so that the DFG support can provide the margin needed for excellence in the general research subject chosen. The number of such centers has risen from 114 in 1979 to 128 in 1982; individual 1983 budgets range from about $215,000 to about $2,900,000. Some 31 percent of the DFG's budget is expended in this manner.

Heisenberg Program. In light of US concerns over the support and supply of young scientists, this program is of special interest, even though it involves less than 2 percent of the DFG's funds. It provides full support for 5 years for young scientists--typically under 35 years old--to pursue whatever research wherever they choose. The goal is not merely to support good research; it is to provide positions for young scientists when university positions are very difficult to obtain. Although only 80 percent of the available funds has been awarded each year, DFG officials consider the program successful: half the recipients accept permanent university or research posts before their Heisenberg awards expire.

Central Research Facilities. Occasionally the DFG provides funds for the purchase of major equipment or facilities to be used by researchers throughout the country; many of the research fields thus aided are interdisciplinary. In 1983, these central facilities included equipment for solar physics, seismology, oceanography, geochronology, geophotometry and remote sensing, laboratory animals, mutagenics, and polling methods and analysis.

Other Programs. Miscellaneous projects are supported by the DFG in areas such as libraries and library services, international cooperation and exchange, and coordination and policy.

## Budget Trends

In real terms (allowing for inflation), the DFG's budget has remained nearly constant since 1981--about $294,800,000 in 1981 dollars. DFG officials are optimistic, however, that the next 3 years will be rosier; with 7-percent cash increases, 2- to 3-percent inflation means growth in real terms. Some broad program areas will fare slightly better than others, since small shifts in the distribution of funds among areas are planned: (1) the Normal Procedure and Research Groups will get a slightly increasing share

Table 1

DFG Budget

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|
| Normal/Groups | 130.3* (44.2) | 137.7 (44.7) | 134.4 (41.8) | 148.1 (43.0) | 163.0 (44.1) | 179.0 (45.0) |
| Priority Progs. | 39.1 (13.3) | 44.5 (14.4) | 43.6 (13.5) | 46.8 (13.6) | 49.0 (13.2) | 51.5 (12.9) |
| Spec. Collab. | 91.9 (31.2) | 96.1 (31.2) | 102.8 (31.9) | 107.0 (31.1) | 113.4 (30.6) | 120.2 (30.2) |
| Heisenberg | 3.7 (1.3) | 4.4 (1.4) | 5.3 (1.6) | 6.6 (1.9) | 7.5 (2.0) | 8.3 (2.1) |
| Facilities | 5.0 (1.7) | 5.4 (1.8) | 8.1 (2.5) | 7.6 (2.2) | 7.1 (1.9) | 6.5 (1.6) |
| Other | 24.8 (8.3) | 20.3 (6.7) | 28.0 (8.7) | 28.3 (8.2) | 30.3 (8.2) | 32.3 (8.2) |
| Total | 294.8 (100) | 308.4 (100) | 322.2 (100) | 344.4 (100) | 370.3 (100) | 397.8 (100) |

* Millions of dollars (percent of column total)

(from 41.8 percent in 1983 to 45 percent in 1986); (2) the Heisenberg Program share will rise steadily from 1.6 percent to 2.1 percent; (3) the Central Research Facilities share will fall from 2.5 percent to 1.6 percent; and (4) the shares of the other areas will decrease very slightly. These trends appear to indicate an increased emphasis on the research support of individuals, with a corresponding decrease in the support of centralized projects.

Table 1 gives the approximate budget--both as a percentage of the total and as an absolute amount in millions of dollars (assuming DM 1.00 = $0.36)--for 1981-86 in each of the broad program areas.

*12/13/83*

## ORGANIZATION OF RESEARCH IN NORWAY

*by D.R. Barr. Dr. Barr, formerly at ONR, London, is Professor of Statistics and Operations Research at the Naval Postgraduate School, Monterey, CA.*

Norway, with just over 4 million inhabitants, is a small country in terms of population. Total R&D expenditure in Norway is just under $500 million per year, which is roughly 1½ percent of her gross domestic product. About half of the total R&D spending is in the business sector; a little over half is government funding, of which about half goes to institutions of higher education. The distribution of Norway's R&D funds for 1981, summarized by sector and discipline, is shown in Table 1 (this has been adapted from "Research in Norway," distributed by the Royal Ministry of Foreign Affairs [1981]).

Government R&D is generally administered by a research council system in which councils are attached to various ministries, such as Education, Industry, Agriculture, and Fisheries. The 40-member Norwegian Council for Scientific and Industrial Research (NTNF), for example, is attached to the Ministry of Industry, although it has members representing other ministries as well as various industries and research institutions. The NTNF is responsible for promoting technological and scientific research and for ensuring transfer of research findings to Norwegian industry as a whole. NTNF directly sponsors research in fields such as manufacturing, construction, and shipping; it has also established over a dozen research

Table 1

R&D Funding in Norway by Sector
and Discipline for 1981
(in millions of dollars)

| SECTOR | Business | Public | Foreign | Other | Total |
|---|---|---|---|---|---|
| Business | 157.0 | 53.7 | 3.6 | 8.6 | 222.8 |
| Private nonbusiness | 0.4 | 1.7 | 0.04 | 0.7 | 2.8 |
| Public | 2.7 | 78.9 | 4.9 | 3.6 | 90.1 |
| Universities and colleges | 2.2 | 131.7 | 0.6 | 3.1 | 137.6 |
| Total | 162.3 | 266.1 | 9.1 | 16.0 | 453.4 |
| DISCIPLINE | | | | | |
| Humanities | 0.5 | 18.6 | 0.1 | 0.8 | 20.0 |
| Social sciences | 0.6 | 35.6 | 0.3 | 0.6 | 37.1 |
| Natural science & math | 2.7 | 65.4 | 0.8 | 1.1 | 70.0 |
| Medicine | 0.6 | 42.9 | 0.5 | 2.8 | 46.7 |
| Agriculture | 0.8 | 22.3 | 0.1 | 1.8 | 25.0 |
| Technology | 157.1 | 81.3 | 7.3 | 8.9 | 254.5 |
| Total | 162.3 | 266.1 | 9.1 | 16.0 | 453.4 |

institutes and is directly involved in international research cooperation, such as space research in collaboration with the European Space Agency and the US National Aeronautics and Space Administration.

A second council that should be mentioned is the Norwegian Research Council for Science and the Humanities (NAVF), which is attached to the Ministry of Church and Education. NAVF interacts with university researchers and coordinates and encourages interdisciplinary research. NAVF is also directly engaged in international research projects, such as the European Science Foundation, the United Nations Educational, Scientific and Cultural Organization's Man and the Biosphere program, and the European Incoherent Scatter Radar Facility in the Auroral Zone.

Universities and other higher educational establishments in Norway carry out a major portion of the country's basic research. The country has four universities:

- The University of Oslo, established in 1811, having almost 20,000 students;
- The University of Bergen, established in 1946, with about 8000 students;
- The University of Trondheim, established in 1969 through a federation of several well-established Norwegian institutions, with 8000 students;
- The University of Tromsø, established in 1968, with an enrollment of almost 2000.

In addition, there are a number of colleges, such as the Norwegian School of Economics and Business Administration and the Norwegian School of Architecture. Norway also has several applied research institutes, most of which were originally established by the NTNF. These institutes, though funded by the various ministries, are essentially self-governing through boards composed of researchers and research sponsors. An example is the Institute of Marine Research, which is supported by the Ministry of Fisheries; this institute is responsible for the operation of Norway's fisheries research ships.

*12/5/83*

## SPACE SCIENCE

### INDUSTRIALIZATION OF SPACE IS DISTANT GOAL

*by R.L. Carovillano. Dr. Carovillano is the Liaison Scientist for Space Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1984 from Boston College, where he is Professor of Physics.*

The Royal Society conducted a discussion meeting entitled "Technology in the 1990s: The Industrialization of

Space," on 7 and 8 December 1983 in London. The opening address was given by Kenneth Baker, member of parliament and Minister of State for Industry and Information Technology of the Department of Trade and Industry. Baker reviewed briefly the accomplishments of the space program from Apollo through the Shuttle and pointed out that space has become an area of mature engineering. The assessment must be made in the US and in Europe whether the costly systems now in development have the economy, flexibility, adaptability, and suitability to meet future needs. Future space program developments will be too costly for any single nation, and international cooperation is essential. Baker stated that the European Space Agency (ESA) is the best example of cooperation in high technology and credited ESA with successfully carrying out European commitments made more than a decade ago. Looking ahead, Baker stated that the earnings of developers of space will exceed those of the hardware developers, and that exploiters of space will profit greatly. Space telecommunications is already a big business throughout the world; and markets for space-based services are already large outside of North America.

Conference speakers reviewed current space satellite and tracking capabilities, assessed space business opportunities, discussed financing of space business ventures, and described future space efforts being planned or under development.

G.K.C. Pardoe, Managing Director, General Technology Systems Ltd., and chairman of the UK Remote Sensing Board, presented an overview of the industrialization of space. Opportunities include communication, transportation, education, services, materials development, land use, disaster control, water resources, and technological spin-offs. Difficulties include maintaining and servicing space and ground stations for reliability; the need to provide international cooperation and organization through a coordinated centralized approach; insurance; and the proper interfacing of the financial and technical communities for space ventures. The level of benefits to be gained from current and future technical developments in space will depend crucially on the manner in which the world community organizes itself.

A.K. Jefferis, chief executive of satellite systems, British Telecom International, spoke about the Intelsat global communications system. In terms of the industrialization of space, satellite communication constitutes the largest single application and will continue to be significant, if not dominant, in the foreseeable future.

The International Satellite Organization (Intelsat) began in 1964 with 11 members and one satellite, the Early Bird that was renamed Intelsat 1. Today the organization consists of 104 member nations or signatories; and 17 satellites are operating. The organization is run by a board of governors that consists of about 20 members--one for each of the 13 largest signatories, plus a member for groups of signatories that collectively exceed a designated size. Charges for using the system are based on telephone circuits per annum. Through the years, in equivalent dollars, the usage cost has gone from about $32,000 to its current value of $4,000 per annum per one-half telephone circuit. Usage charges cover all operational costs and overhead, depreciation, and a 14 percent per year average return on capital invested.

Intelsat covers the globe in three sectors--designated the Atlantic Ocean sector, the Pacific Ocean sector, and the Indian Ocean sector. The bulk of the traffic is telephone usage and data transmission by means of telephone circuitry. Television has become a heavy user, too. The Atlantic region is the largest user, about three times larger than the Indian sector and four times larger than the Pacific sector. As new satellites are developed, the satellites in use are rotated cleverly from high- to low-use regions to provide adequate coverage with older or earlier generation equipment. Intelsat 4, built by Hughes, and Intelsat 5, the three-axis stabilized current generation satellite built by Ford Aerospace, are in use now. Intelsat 6 is under construction by Hughes and will have about 30,000 telephone circuits, TV capability, and a digital data transmission system that effectively amplifies the available circuits by a factor of 2 to 2.5.

In the past, high growth rates in international communications have produced a new generation Intelsat satellite about every 5 years. Practical factors such as frequency-band limitations, development costs, and need preclude the liklihood of such continued growth. Intelsat 6 is so expensive and large that its implementation will affect the satellite replacement philosophy used in the past. Intelsat 6 is far too large to rotate into low-use sectors even late in its operational lifetime, and it would be more practical to use earlier generation satellites for that purpose.

In a recent development, European governments have established ECS, a regional communications satellite system that will become operational soon and will be used into the 1990s. Satellites cannot compete with terrestrial networks for local telecommunications. ECS is intended to prepare the telecommunications industry for the large world markets requiring intermediate distance coverage in the near future.

M.Y. Demerliac, Director General of Eurospace, Paris, spoke about the communications system in Africa and the recommended use of satellites. The current communications system in Africa is limited primarily to telecommunication services between capital cities and between capital cities and Europe by means of Intelsat. There are about 7 to 70 direct exchange lines per 10,000 inhabitants. About 80 percent of the telephones are in the capital cities, and almost none are in rural areas that contain more than 80 percent of the population. Generally, radio coverage and (especially) quality are poor. Television exists almost exclusively in capital cities.

Eurospace recommends the establishment of a dedicated satellite system (AFSAT) complemented by a large number of small, inexpensive ground stations that would provide wide coverage into rural and remote areas. Development costs would be about $800 million for the ground segment and $200 million for the satellite segment. Operational costs would be about $15 million per year, including $5 million per year for the governing African agency. In providing telecommunications coverage, ground systems are cheaper than satellites for connecting distances less than 50 to 100 km. The plan is to finance the program through intergovernmental contributions and risk capital from the private sector.

P.L.V. Hickman, managing director of the Space Division, British Aerospace, spoke on the British direct broadcast system known as Unisat. Unisat is a successful commercial venture formed by several British corporations and financed from the private sector. Hickman indicated that capital leasipg was used in place of equity financing or outright loans. The approach requires adequate insurance against instant satellite mortality and is available through New York and London. The 10-year lifetime of the satellites and the use of Ariane, the European rocket launcher, have lowered insurance rates. Once in space, satellites have proven to be very reliable. Cable communication will be slow in coming and the plan is to provide direct broadcast to the home user in the coming years.

O. Lundberg (director general, INMARSAT) spoke on maritime satellite communications needs that led to the establishment of the International Maritime Satellite Organization (INMARSAT) in 1979; its headquarters are in London. Membership in INMARSAT is open to all nations; currently there are 38 members or signatories. Because of financial uncertainties, the organization initially required backing from public funds and from ESA. Today capital needs are provided by the signatories in proportion to their investment shares, and the organization levies usage fees to operate on a sound economic basis. The largest investment shares are held by the US (23.4 percent), the USSR (14.1 percent), the UK (9.9 percent), Norway (7.8 percent), and Japan (7.9 percent).

The purpose of INMARSAT is to provide the space system needed to improve maritime communications for efficient ship operation, navigation and position determination, safety, and distress. Rescue operations at sea are notoriously expensive and dangerous--so a large amount of money can be saved if ships are kept out of trouble. This saving helps underwrite large technological programs. The main elements of the INMARSAT system are the space segment with associated ground support facilities, coastal earth stations, and ship earth stations. INMARSAT funds the space segment, the signatories generally fund the coastal stations, and private companies fund the ship stations.

S. Metzger, former chief scientist at the US Communications Satellite Corporation, reviewed the development of earth-based terminals for communications satellites. The latest antennas will operate in two polarization modes. In effect there will be two sets of amplifiers in the satellite, one transmitting in the vertical polarization mode and one in the horizontal. No additional intermediate polarization ranges will be available. The latest business service antennas will be only 3.5 m in diameter.

Admiral W. Ramsey described the navigation satellites of the US Navy. TRANSIT is the current navigation system and it will be replaced by NAVSTAR in a few years. The TRANSIT system consists of six satellites in orbit--five operational and one spare. The system is 19 years old, and two of the satellites have been in use for 17 years. The original design lifetime of the satellite was merely 3 years, so the system has been very successful. The US Navy

has 800 user sets. Worldwide there are 3700 sets, mostly owned by commercial users. The current cost of the user set is $2700, and the cost reduction from its original value of $65,000 has opened the market. At only 1 to 4 hours per day, coverage is not continuous; the system is vulnerable; and the resolution, 160 m at best, is less than needed.

The NAVSTAR, or Global Positioning System (GPS), will use 18 satellites orbiting at 10,900 nautical miles with a 12-hour period. Global coverage will be provided by orbiting six satellites in each of three planes of motion. With three satellites viewing a target area, three-dimensional information and a resolution of about 20 m. With a fourth satellite viewing, dynamical characteristics of the target area are also determined. About 20,000 user sets are planned for all segments of US military forces.

J. MacArthur (director, Kleinwort-Benson Ltd., London) discussed financing space ventures. A shifting emphasis is taking place in the financing of space from the public to the private sector. Risks are high in space, but the payoff potential can be even higher. Possible means of financing space ventures include joint partnerships, international conglomerations involving different currencies, and risk venture capital. Johnson and Johnson and McDonnell Douglas Corp. have teamed up in a space pharmaceutical effort in the amount of $150 to 200 million. Financial backing by banks will require guarantees that will probably have to be provided by governments. Loan techniques for space are developing, and forms such as leasing may be suitable.

MacArthur emphasized that the space sector, in attempting to operate on the private market, will have to compete with the profitability available from alternative investment possibilities. Risk assessment and reward potential would be crucial considerations. The continued success of the Shuttle will improve the possibility of private financing because of insurability and demonstrated reliability.

At the moment the expenditure of private funds in space is very small. With further successes in space, government encouragement could stimulate private investments. Perhaps in 15 years or less, financial institutions will consider funding ventures in space as they now do offshore oil rigs and nuclear power plants. In the long term, space will compete as just another business for private investments and financing.

The rest of the meeting related to current and planned systems that would significantly impact the commercialization of space. Ariane, the Shuttle, European and US remote sensing programs, and the development of space data systems were discussed. S. Tilford (Environmental Sciences Division, US National Aeronautics and Space Administration [NASA]) discussed NASA's space remote-sensing program and the cross-disciplinary approach to determine basic geophysical processes through missions such as LANDSAT, UARS, TOPEX, and SEASAT. P. Anson (Marconi Space and Defence Systems, UK) similarly described the European Remote Sensing Satellite (ERS-1). Tilford, Anson, and D.D. Hardy (Royal Aircraft Establishment, UK) emphasized the dramatic improvements needed in data processing and handling for remote processing information to be available in anything near real-time. Possible commercial interests in remote sensing were suggested for products such as soil moisture indices, temperature indications of sea nutrients, wave-height determinations, weather monitoring, and determination of pollution zones.

Throughout the program, speakers referred to the US space station as though it were an approved program that would expeditiously develop the facility. The space-station concept is highly controversial in the US, and both the Department of Defense and the Space Science Board of the National Academy of Sciences (NAS) have offered substantial opposition to it. R.F. Freitag (Space Station Task Force, NASA) spoke about space stations and their potential uses. Freitag is, of course, a strong proponent of the space-station concept and dismissed opposing viewpoints as temporary in view of White House expectations that the space program will take an exciting direction, with an expanded and permanent role for man in space.

Briefly, the viewpoint of the US scientific community is that effective use of the Shuttle for scientific purposes, such as for launching large instruments or laboratories and for servicing and retrieving payloads in orbit, should have top priority in the next decade. In evaluating a NASA proposal for a manned space station with proposed scientific missions for the 1990s, the Space Science Board stated that "few of these missions would acquire significant scientific or technical enhancement by virtue of being implemented from this space station," and that the requirements to carry out all top-priority missions now under development or consideration by NASA

could be provided by the Shuttle. An underlying concern of the space science community--based on long experience--is the inevitable cost overruns of large programs and the relatively low priority science has in resulting budgetary battles. The space science community is small and fragile, and further long delays in program opportunity would seriously undermine its vitality or existence.

In presenting this symposium, the Royal Society assembled a distinguished body of executives, engineers, scientists, and other professionals to discuss the future commercialization of space. Emphases were given to communications; materials development, particularly pharmaceuticals; manufacturing; transportation; remote sensing; and financing requirements. Further symposia of this sort will be needed to articulate the issues and problems relating to the possible commercialization of space and to assemble proponents.

Though enthusiasm and optimism exist, commercialization certainly appears to be a remote goal. Despite the fact that sustained progress in space research and technology is required for industry to take root and prosper, NASA funds for space research and technology have actually declined steadily since 1962. In addition, although ESA, France, Germany, the UK, and Japan all expressed interest in participating with NASA to develop the space station, their collective financial backing offered to the effort was no more than 10 percent of the estimated cost.

The meeting was organized by Sir Harrie S.W. Massey, FRS, and Mr. G.K.C. Pardoe. The meeting was opened with the report that Massey had died 11 days earlier. Massey had a distinguished scientific career that encompassed many fields, including atomic and molecular physics, particle physics, astrophysics and space research. He is recognized throughout the world as a proponent of space exploration and has had a major influence on the development of the British space effort since its inception.

Reference

*News Report*, National Academy of Sciences, Vol 32, No. 8 (October 1983), 23-24.

*12/14/83*

## STATISTICS

THE NORWEGIAN COMPUTING CENTER

*by D.R. Barr. Dr. Barr, formerly at ONR, London, is Professor of Statistics and Operations Research at the Naval Postgraduate School, Monterey, CA.*

The Norwegian Computing Center (NCC, P.O. Box 335-Blindern, Oslo 3, Norway) employs about 60 research professionals, mostly concerned with data technology and the associated use of quantitative methods and computers. The research is organized into three branches: data technology, quantitative methods, and applied data processing.

Data Technology

This branch has been working on three projects: work stations for programmers, programming languages and translations, and data networks. In all of these, there has been interaction with university researchers in Norway and elsewhere. The computer language SIMULA has been developed in the languages project--this system is now implemented on a variety of computer models and is widely used. Recently, the "SIMULA machine" (the Mach-S work station) has been developed, and it is now undergoing testing and modification.

Applied Data Processing

This branch works on projects in a wide range of applications related to organizational and social aspects of the use of data technology. Generally the applications concern methods of constructing and using data systems, taking into account technology, organization, and the working environment.

Quantitative Methods

This is the largest branch at NCC; it is concerned with research on mathematical and statistical theory, methods, and applications. Much of the work carried out in this branch is done on contract for various ministry and industry groups. Recent projects have included work related to natural resources (particularly use of remote sensing data for exploration), medicine, public administration, and computer-assisted map production.

The latter project, called the Research Program on Mapping and Spatial Data Management, has increased in size and currently accounts for about 40 percent of NCC's contract activities. The mapping program is a 5-year project which started in 1982. Last year, total Norwegian government funding for the program amounted to roughly $1.5 million, with a similar amount contributed by private industry and mapping system

users. The program is composed of seven major efforts, involving:

- Developing new mapping equipment
- Developing general methods in mapping and spatial data handling
- Finding methods for terrestrial resource mapping
- Mapping coastal areas and hydrographic mapping
- Establishing mapping communication networks, utility networks, and similar systems
- Navigating and positioning digital maps and spatial data.

One particularly interesting facet of this program is the development of new interactive cartographic work stations. The work on automated cartography, which was begun at NCC in 1974, is directed by Dr. Truls Kjølberg. The group has worked on a new computer-assisted cartography system called MIKADO, in collaboration with the Norwegian computer firm Simulation Excel A/S and with other NCC groups, such as the ones working on the Mach-S SIMULA machine and Ethernet on the SIM-X S-2000 computer system. The SIM-X S-2000 has been developed as a special computer for picture processing which, according to Kjølberg, bridges the gap between raster and vector data processing. It is a stand-alone unit with a SIMULA compiler which may be linked to a host computer via Ethernet. It drives a high-resolution graphics screen, an input laser scanner for maps and photographs, and an output laser scanner for plotting.

MIKADO has four main modules, which handle data capture from existing maps, data capture from aerial photographs, digital terrain modeling, and landscape generation. The goal is to create a cartographic work station which gives cartographers a chance to use their skills, while exploiting data-processing technology in carrying out routine map-making processes (mechanized drafting processes). This should produce superior maps at costs far lower than those for maps making more extensive use of field work.

In addition, digitized map information can be transformed or merged in various ways to produce relatively inexpensive derivative map products (such as changes in scale, production of stereo pairs, or maps emphasizing features such as buildings, roads, and power lines). One module of MIKADO, particularly useful in updating existing maps, compares an existing digital map with a newly taken aerial photograph of the same area. Using pattern recognition procedures, objects of specified spectral signature on the photo can be identified and compared with those in the map data base. Thus changes in features such as roads and buildings, which change relatively often, can be detected and incorporated into the map data base. Fortunately, these features happen to have easily identifiable spectral signatures, according to Kjølberg.

Another project at NCC concerns statistical analyses of data related to wind-transported pollutants, particularly those causing acidification of precipitation. For several decades, southern Scandinavia has been affected by "acid rain"; measurements have been made in Scandinavia since the mid-1950s. The increased acidity is caused mainly by sulphate carried by winds from industrial areas. Analysis of wind directions and other meteorological conditions have shown that most of these pollutants are coming from the south. They may be transported over very long distances, on the order of several thousand kilometers. Since 1972 there has been a leveling out in sulphate concentrations in precipitation.

Dr. E. Damsleth has been conducting a study of long-range transport of air pollution into Norway. Time-series analysis and related techniques have been widely used in analyses of air pollution, but Damsleth uses what he calls intervention analysis and transfer function modeling to describe the impact of the prevailing wind direction on sulphate concentration in the air. Using observations from one station in southern Norway, Damsleth has shown that a standard auto-regressive moving average (ARMA) model of order 1 (an AR(1) model) can be fitted to the log-transformed data.

Damsleth divided the 360-degree compass into eight sectors, and classified each day as "belonging" to a sector if more than half the wind trajectory on that day fell within the sector. (If not, the day was not classified; about 23 percent of all days are of this category.) After considerable data analysis, Damsleth adopted an ARMA (1,3) model for daily log-concentration as a function of indicator variables representing daily wind sectors. He was also able to fit monthly log geometric mean of daily concentration, $W_t$, with a "sinusoidal" model $\ln W_t - .10 = .635_t - 1.05C_t + n_t$, where $S_t = \Sigma \sin((Z_i - 1)\pi/4)/N_t$, where in turn $Z_i$ is the sector value for day i, $N_t$ is the number of classifiable days in the month t, and the sum is over such days; $C_t$ has a similar definition in terms of cosines, and $n_t$ is a noise term.

Damsleth found close agreement between the daily and monthly models with respect to the effects of wind direction on sulphate concentration, although quite different noise models are involved. He concludes that the wind direction has a significant impact on sulphate concentration at the observation station involved. The log-transformed concentration has an almost perfect sinusoidal relationship with wind direction. Damsleth now intends to apply these methods to data from several additional stations throughout Norway.

*12/13/83*

# NEWS & NOTES

## UK MOD DROPS SUPPORT OF ADA LANGUAGE

The British Ministry of Defence (MoD) has decided to stop its financial support of development of the ADA computer language, according to an article in *The Times* (London), 6 December 1983. The US Department of Defense and the North Atlantic Treaty Organization have scheduled ADA to become the military standard language starting next year, although it is widely rumored that actual introduction of the language may have to be delayed due to the difficulties in development of the ADA programming support software.

A group of British software companies have formed the ADA Group to work on the ADA Programming Support Environment software under joint sponsorship of the British MoD, British Telecom, The General Electric Co., Ltd. (GEC, a British company), and Plessey. It is reported that British Telecom is also pulling out of the project, although GEC, Plessey, and private software companies are expected to carry on.

*D.R. Barr*
*12/7/83*

## TWO EUROPEAN ASSOCIATIONS PROMOTE RESEARCH IN PERSONALITY AND SOCIAL PSYCHOLOGY

In May 1982, the First European Conference on Personality was held at Tilburg University, The Netherlands. The success of this conference led to a decision to publish an edited collection of the best contributions (look for Bonarius, Van Heck, and Smid, forthcoming), and to form the European Association of Personality Psychology. The new association will be formally founded at its Second Conference, to be held at the Center for Interdisciplinary Research, University of Bielefeld, Wellenberg 1, Federal Republic of Germany, from 16 through 19 May 1984. Invited speakers include: H.J. Eysenck, Institute for Psychiatry, London; P. Roubertoux, Institut National d'Orientation Professionelle, Paris; H. Thomae, University of Bonn; B. Lomov, University of Moscow; and J. Reykowsky, Polish Academy of Sciences, Warsaw. There will also be invited symposia on human action and motivation, the social construction of personality, the individuality concept, and experimental perception- and process-oriented personality research. Information about the association and the conference can be obtained from Dr. G.L.M. Van Heck, Department of Psychology, Tilburg University, Box 90153, 5000 LE Tilburg, The Netherlands.

The European Association of Experimental Social Psychology is a somewhat older organization but with several new initiatives. Its 20th anniversary General Meeting will be held at Tilburg University, The Netherlands, from 9 through 12 May 1984. Special themes to be emphasized are social psychology and education, personality and social psychology, the development of social behavior, universals in social behavior, and the teaching of social psychology. The association has also begun holding East-West Meetings, in addition to its General Meeting, with the most recent of these occurring at Varna, Bulgaria, from 16 through 20 May 1983. Featured symposia included: social influence on human motivation, cultural and environmental influences, social cognition, interpersonal and intergroup conflict, self concept and control, developmental issues, interpersonal behavior, emotion regulation and expression, and work motivation (for abstracts of papers, see Newsletter, European Association of Experimental Social Psychology, [Kent, England: University of Canterbury, June 1983]). Information regarding this association and its publications and conferences can be obtained from Dr. Geoffrey Stephenson, Secretary of EAESP, Social Psychology Research Unit, University of Canterbury, Kent, England CT2 7LZ.

### Reference

Bonarius, H., G. Van Heck, and N. Smid, eds., *Personality Psychology in Europe: Theoretical and Empirical*

*Developments* (London: Lawrence Erlbaum Assoc., forthcoming).

*Richard E. Snow*
*12/12/83*

## EUROPEAN SOLAR PHYSICS MEETING

The Fourth European General Meeting on Solar Physics, entitled "The Hydromagnetics of the Sun," will be held from 1 through 3 October 1984 in Utrecht, The Netherlands. Three sessions are planned: I, Convection and Rotation; II, Generation and Structure of the Magnetic Fields; and III, Structure and Stability of the Corona. Invited reviews and contributed papers will be included in each session. In session I, the reviews will be on solar rotation, solar convection, and solar oscillations; in session II, the dynamics of magnetic flux concentrations, and nonlinear dynamos; in session III, coronal structure, Alfvén wave heating, and the coronal energy balance.

The European solar physics meetings have been held triennially since 1975. Previous meetings were in Florence (1975), Toulouse (1978), and Oxford (1981).

For further information, contact:

Dr. P. Hoyng
The Astronomical Institute at Utrecht
Space Research Laboratory
Beneluxlaan 21 - 3527 HS - Utrecht
The Netherlands

*R.L. Carovillano*
*12/16/83*

## ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Third UK Solar Maximum Mission Workshop, Oxford, UK, 26-28 March 1984.

Vacuum 84--Technological Aspects of Surface Treatment and Analysis Conference, York, UK, 1-4 April 1984.

Sixth European Conference on Surface Science (ECOSS-6), York, UK, 1-5 April 1984.

International Symposium on the Properties and Applications of Metal Hydrides IV, Eilat, Israel, 3-9 April 1984.

Royal Statistical Society 150th Anniversary Conference, London, 4-6 April 1984.

Second International Meeting on Lithium Batteries, Paris, France, 25-27 April 1984.

International Conference on the Physics of Highly Ionised Atoms, New College, Oxford, UK, 2-5 July 1984.

International Conference on Laser Processing and Diagnostics--Applications in Electronic Materials, Linz, Austria, 15-19 July 1984.

Tenth General Assembly of the European Geophysical Society, Louvain-la-Neuve, Belgium, 30 July - 4 August 1984.

Fifth International Symposium on Gas Flow and Chemical Lasers, Oxford, UK, 20-24 August 1984.

Fatigue '84, Birmingham, UK, 3-7 September 1984.

International Conference on Digital Signal Processing, Florence, Italy, 4-8 September 1984.

Second International Conference on Science of Hard Materials, Rhodes, Greece, 23-28 September 1984.

Ninth European Specialist Workshop on Active Microwave Semiconductor Devices, Veldhoven, The Netherlands, 10-12 October 1984.

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## SCIENCE NEWSBRIEFS FOR DECEMBER

**The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during December. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR London.**

| *Science Newsbrief* Number | Title |
|---|---|
| 1-4-83 | UK Stimulates Industrial Innovation and Technology Transfer, by James W. Daniel. |
| 1-5-83 | Space Science in Europe: Cooperation and Competition, by R.L. Carovillano. |
| 1-6-83 | Equation Characterizes Public Key for Encryption System, by D.R. Barr. |

## DECEMBER MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during December. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR London.

| MASB Number | Title |
|---|---|
| 128-83 | A Low Profile Forklift Truck for Shipboard Use |
| 129-83 | Closed Cycle Diesel Submersible--Revisited |
| 130-83 | Laser Weapon Research and Development |
| 131-83 | European Aerospace Update |
| 132-83 | The Sprite Remotely Piloted Helicopter |
| 133-83 | UK's ADA Program Losing Support |
| 134-83 | Self-Powered Buoy Using Wave Energy |
| 135-83 | A British Seawolf Missile Successfully Intercepts an EXOCET Antiship Missile |
| 136-83 | UK Royal Navy Plans Secure Facsimile for Meteorology and Oceanography (CONFIDENTIAL) |
| 137-83 | Fourth Quarterly Index 1983 |
| 138-83 | Annual Subject Index 1983 |

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## EUROPEAN VISITORS TO THE US SPONSORED BY ONR, LONDON

| Visitor | Areas of Interest | Organizations to be Visited | Want Information? Contact at ONRL |
|---|---|---|---|
| Dr. C.A. Brookes<br>Dept. of Engr. Science<br>University of Exeter<br>North Park Road<br>Exeter, Devon, EX4 4QF | Engineering Science/ Hardness Testing | Naval Research Laboratory<br>NSWC<br>Whiteoak, MD<br>(9-20 July 84) | James W. Daniel |
| Dr. Norman Louat<br>University of Oxford<br>Dept. of Metallurgy & Materials Science<br>Parks Road<br>Oxford OX1 3PH | Materials Science/ Dislocation Theory | Naval Research Laboratory<br>(Jan.-April 84) temporary research appointment | James W. Daniel |
| Dr. Herman Schöyer<br>Delft Univ. of Tech.<br>Dept. of Aerospace Engineering<br>P.O. Box 5058<br>2600 GB Delft<br>The Netherlands | Ramjet Propulsion | NWC, China Lake<br>(16 April 84)<br>NPS, Monterey<br>(12 April 84) | CDR J. Strada |
| Prof. David Tabor<br>Univ. of Cambridge<br>Cavendish Laboratory<br>Madingley Road<br>Cambridge CB3 0HE | Physics/Friction & Wear | ONR HQ<br>Naval Research Laboratory<br>NSWC<br>(9-20 July 84) | James W. Daniel |

## EUROPEAN VISITORS (CONT'D)

| Visitor | Areas of Interest | Organizations to be Visited | Want Information? Contact at ONRL |
|---|---|---|---|
| Dr. R.J.H. Wanhill<br>Materials Dept.<br>Natl. Aero. Lab., NLR<br>P.O. Box 153,<br>8300 AD Emmeloord<br>The Netherlands | Materials Science/ Fatigue & Fracture Mechanics | NADC, Warminster, PA<br>Naval Research Laboratory<br>(Late March-early April 84) | James W. Daniel |
| Dr. T.P. Obrenovitch<br>CERB. HIA, Sainte Anne<br>F-83800, Toulon Naval<br>France | Hyperbaric Physiology | Beth Israel Medical Cen., NY<br>(21 May 84)<br><br>Univ. of Penn. Medical Center<br>(22-23 May 84)<br><br>Natl. Inst. of Health, Bethesda, MD (24 May 84)<br><br>Uniformed Serv. Univ. of the Health Sciences Bethesda, MD<br>(25-26 May 84)<br><br>Gerontology Research Center Baltimore, MD<br>(27 May 84)<br><br>George Washington Univ. Med. School Washington, DC<br>(28 May 84) | T. C. Rozzell |


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